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RTN 3-23246

Volume 1: Text

Phase II Comprehensive Site Assessment, Method 3 Risk Characterization, and Phase III Remedial Action Plan

50 Tufts Street, Somerville, Massachusetts

Submitted to:
UniFirst Corporation
68 Jonspin Road
Wilmington, MA 01887

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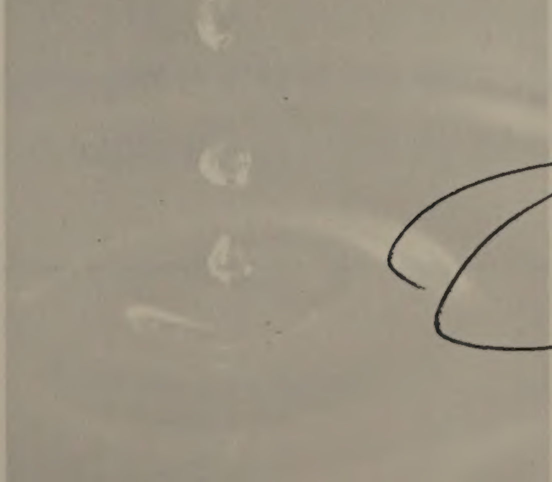

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Table of Contents

Acronyms xiii

Executive Summary xvii

1. Introduction 1
- 1.1 Background 1
- 1.2 Purpose 2
- 1.3 Scope 2
- 1.4 Submittals 3
- 1.5 Public Participation 3
- 1.6 Conceptual Site Model 4
  - 1.6.1 Site History Overview and Current Conditions 4
  - 1.6.2 Potential Contaminant Sources 5
  - 1.6.3 Contaminant Distribution 5
  - 1.6.4 Source Characterization 7
  - 1.6.5 Receptors and Potential Exposure Pathways 8

2. Disposal Site Information [310 CMR 40.0835(4)(a)(b)] 9
- 2.1 Site Location and Description 9
  - 2.1.1 The Property Location and Description 9
  - 2.1.2 Residential and Commercial Properties Location and Description 9
  - 2.1.3 Capuano Center Location and Description 10
- 2.2 Disposal Site Map 11
- 2.3 Site Vicinity 11
  - 2.3.1 Nearby Chlorinated VOC DEP-listed Releases 11
- 2.4 Natural Resource Areas and Surrounding Land Use 13
- 2.5 Current Site Utilities 14
  - 2.5.1 The Property Utilities 14
  - 2.5.2 Residential and Commercial Properties Utilities 14
  - 2.5.3 Capuano Center Utilities 15

3. Disposal Site History [310 CMR 40.0835(4)(c)] 16
- 3.1 Ownership and Operation History of the Site 16

3.1.1 The Property Ownership and Operation History 16
3.1.2 Residential and Commercial Property Ownership and Operation 18
3.1.3 Capuano Center Ownership and Operation 18
3.2 Site Release History 19
3.2.1 The Property 19
3.2.2 Residences and Commercial Properties Release History 20
3.2.3 Capuano Center Release History 21
3.3 Site OHM Use and Storage History 21
3.3.1 The Property OHM Use and Storage History 21
3.3.2 Residential and Commercial Properties OHM Use and Storage History 23
3.3.3 Capuano Center OHM Use and Storage History 23
3.4 Waste Management 23
3.4.1 The Property 23
3.4.2 Residential and Commercial Properties 24
3.5 Environmental Permits and Compliance 24
3.5.1 The Property 24
3.5.2 Residential and Commercial Properties 25

4. Site Geology and Hydrogeology [310 CMR 40.0835(4)(d)] 26
4.1 Background 26
4.2 Sanborn Head: 2002-2003 26
4.3 GeoInsight: 2004 27
4.4 GEI: 2006-2008 27
4.4.1 Monitoring Well Installation and Soil Sampling 27
4.4.2 Shallow Soil Sampling 29
4.4.3 Subsurface Soil Vapor Monitoring Point Installation and Sampling. 30
4.4.4 Groundwater Sampling 30
4.5 Geophysical Survey 31
4.6 Regional Geology 32
4.6.1 Fill History 32
4.6.2 Surficial Geology 32
4.6.3 Bedrock Geology 33
4.7 Topography 33
4.8 Geology Description 34
4.9 Groundwater System 34
4.9.1 Groundwater Level Measurements 35

4.9.2 Groundwater Gradients 35
4.10 Hydraulic Conductivity Testing 35
4.10.1 In-Situ Permeability Testing 35
4.10.2 Results of Hydraulic Conductivity Testing 36
4.11 Underground Utility Evaluation 37
4.11.1 Physical Characteristics of Utilities 37
4.11.2 Air VOC Measurements 38

5. Subsurface Investigation Testing Results 39
5.1 Soil Testing Results 39
5.1.1 Soil Borings – Chemical Testing 39
5.1.2 Shallow Soil Samples: Site-Wide 39
5.1.3 Shallow Soil Samples: Capuano Community Gardens 40
5.1.4 Shallow Soil Samples: 95R Franklin Street 40
5.2 Subsurface Soil Vapor Testing Results 41
5.3 Groundwater Testing Results 41
5.3.1 DEP Screening at the Capuano Center 42
5.3.2 Irrigation Well Sampling Results 43
5.4 Underground Utilities – Water Testing Results 43

6. The Property Indoor Air Evaluation and Mitigation 44
6.1 SHA Investigation (2002) 44
6.2 Mitigation Measures Installed by GEI 44
6.3 Indoor and Outdoor Air Sampling at the Property 45
6.4 Results of Indoor and Outdoor Air Testing Results 45

7. Residential and Commercial Properties Indoor Air Evaluations and Mitigation 47
7.1 DEP Indoor Air Evaluation along Tufts Street (2005) 47
7.2 GEI Indoor Air Evaluation along Tufts Street (2006) 47
7.3 GEI Additional Indoor Air Evaluation (Winter 2007) 48
7.4 GEI Vapor Intrusion Evaluation 49
7.4.1 Evaluation Process 49
7.4.2 Criteria for Mitigation in Residences 49
7.4.3 Criteria for Mitigation in Commercial Buildings 50
7.4.4 Criteria to Conduct Indoor Air Testing in Residences 50
7.5 GEI Sub-Slab Soil Vapor Evaluation 50

- **7.5.1** Sub-Slab Soil Vapor Sampling 50
- **7.5.2** Sub-Slab Soil Vapor Testing Results 51

7.6 GEI Indoor Air Evaluation (2008) 51
- **7.6.1** Indoor Air Sampling 51
- **7.6.2** Indoor Air Testing Results 51

7.7 EPEM Vapor Mitigation 52
- **7.7.1** Temporary Measure - Air Purifiers 52
- **7.7.2** Sub-Slab Depressurization Systems 53
- **7.7.3** Vapor Barrier and Venting System 53

7.8 Additional Indoor Air Testing 54

7.9 Class B Response Action Outcome-Partial Statement 55
- **7.9.1** Residences and Commercial Buildings at the Site Boundry 55
- **7.9.2** Residences and Commercial Buildings with Sub-slab and/or Indoor Air Data 55

7.10 Outdoor Air Sampling and Testing 56
- **7.10.1** Outdoor Air Sampling 56
- **7.10.2** Outdoor Air Testing Results 56

7.11 60 Tufts Street 56
- **7.11.1** SVE System 57
- **7.11.2** Pilot Extraction Test 57

8. Capuano Center Property Indoor Air Evaluation and Mitigation 58

8.1 Initial Indoor Air Testing 58

8.2 Indoor Air Quality Evaluation 58

8.3 Sub-Slab Depressurization System 59

8.4 Mitigation Monitoring 59
- **8.4.1** Monthly Indoor and Outdoor Air Sampling 59
- **8.4.2** Monthly Indoor and Outdoor Air Sampling Analysis Results 60

9. Environmental Fate and Transport [310 CMR 40.0835(4)(e)] 61

9.1 Physical and Chemical Properties of Site Contaminants ... 61

9.2 Principal Chlorinated VOCs 61
- **9.2.1** Tetrachloroethylene (PCE) 62
- **9.2.2** Trichloroethylene (TCE) 62
- **9.2.3** 1,1,1-Trichloroethane (TCA) 62

9.3 Groundwater Transport and Retardation Mechanisms 62

9.3.1 Groundwater Flow 63
9.3.2 Diffusion 63
9.3.3 Dispersion 63
9.3.4 Sorption 63
9.3.5 Volatilization 64
9.3.6 Degradation of Chlorinated VOCs 64
9.3.7 Surfactants 65
9.4 Dense Non-aqueous Phase Liquid 66
9.5 Vapor Intrusion 67
9.5.1 Vapor Intrusion Transport Mechanism 67
9.5.2 Potential for COPCs to Impact Indoor Air Quality 67
9.6 Utilities as Migration Pathways 68

10. Contaminant Nature and Extent [310 CMR 40.0835(4)(e)(f)] 69
10.1 MCP Definitions 69
10.2 Nature of Contamination 69
10.3 Source Characterization 70
10.4 Extent of DNAPL 70
10.4.1 Assessment of the Presence of DNAPL 70
10.4.2 Location of DNAPL 71
10.4.3 Composition of DNAPL 72
10.4.4 Stability of DNAPL 72
10.5 Extent of Chlorinated VOCs in Soil 73
10.6 Extent of Chlorinated VOCs in Groundwater 73
10.6.1 Shallow Overburden Groundwater 74
10.6.2 Deep Overburden and Bedrock Groundwater 74
10.6.3 Source and Plume Stability and Plume Response Time 74
10.7 Extent of Chlorinated VOCs in Subsurface Soil Vapor 76
10.8 Extent of Chlorinated VOCs in Indoor Air 76
10.9 Extent of Chlorinated VOCs in Underground Utilities 77
10.10 Characterization of Background Conditions 78

11. Method 3 Risk Characterization [310 CMR 40.0900] 79
11.1 Introduction 79
11.2 Current and Reasonably Foreseeable Site Activity and Use 79
11.3 Potential Human Receptors 79

11.4 Potential Environmental Receptors 80
11.5 Identification of Soil and Groundwater Categories............ 81
  11.5.1 Soil Categories 81
  11.5.2 Groundwater Categories 82
11.6 Summary of Analytical Results... 82
11.7 Hot Spot Evaluation 82
11.8 Compounds of Potential Concern...................................... 83
11.9 Exposure Pathways 83
11.10 Identification of Exposure Point Concentrations 84
11.11 Risk of Harm to Human Health... 85
11.12 Risk of Harm to Public Safety and Welfare........................ 85
11.13 Risk of Harm to the Environment...................................... 85
11.14 Uncertainty Analysis... 86
11.15 Conclusions 86

12. Representativeness Evaluation and Data Usability Assessment 87

12.1 Introduction 87
12.2 Site Specific List of Chlorinated VOCs 87
12.3 Representativeness Evaluation... 88
  12.3.1 Conceptual Site Model.. 88
  12.3.2 Use of Field/Screening Data 88
  12.3.3 Sampling Rationale and Spatial Distribution.................... 89
  12.3.4 Storm Drains and Sewers... 91
  12.3.5 Temporal Distribution of Samples................................... 91
  12.3.6 Field Completeness... 94
  12.3.7 Data Inconsistencies and Uncertainty............................. 95
12.4 Data Usability.. 97
  12.4.1 Appropriateness of Analytical Methods 98
  12.4.2 Appropriateness of Reporting Limits............................... 99
  12.4.3 Data Review and Validation 99
  12.4.4 Field Data Usability 100
  12.4.5 Rejected Data.. 100
  12.4.6 Presumptive Certainty.. 101
12.5 Statement of Suitability 102

13. Phase III Remedial Action Plan 103
13.1 Summary 103
13.2 Regulatory Requirements 104
13.2.1 Feasibilty 104
13.2.2 Initial Screening Evaluation (ISE) 105
13.2.3 Detailed Evalution of RAAs 105
13.2.4 Reponse Action Performance Standards 107
13.2.5 Performance Standards 107
13.2.6 Source 107
13.3 Risk-Based Remedial Objectives 108
13.4 Site-Specific Characteristics 109
13.5 Initial Screening Evaluation 110
13.6 Description of Remedial Action Technologies Retained for Detailed Evaluation 111
13.6.1 Exposure Pathway Elimination Measures 111
13.6.2 Soil Vapor Extraction 112
13.6.3 Dual-Phase Extraction 112
13.6.4 Chemical Oxidation 113
13.6.5 Groundwater Extraction (Hydraulic Control) 113
13.6.6 Monitored Natural Attenuation 113
13.6.7 Institutional Controls 113
13.7 Development of RAAs 114
13.7.1 Common RAA Components – EPEMs with AULs 114
13.7.2 Detailed Evaluation Criteria 114
13.8 Remedial Action Alternatives Evaluations 115
13.8.1 RAA1 – Site-wide EPEMs and MNA 115
13.8.2 RAA2 – SVE at the Property, Site-wide EPEMs, and MNA 117
13.8.3 RAA3 – DPE at and Immediately East of the Property, MNA, and Downgradient EPEMs 120
13.8.4 RAA4 – Chem-Ox at and Immediately East of the Property, MNA, and Downgradient EPEMs 124
13.8.5 RAA5 – Hydraulic Control, MNA, and Site-wide EPEMs 127
13.9 Qualitative Scoring of RAAs 131
13.9.1 Effectiveness 131
13.9.2 Reliability 131
13.9.3 Implementation Difficulties 132
13.9.4 Cost 132
13.9.5 Risks 132

13.9.6 Benefits 133
13.9.7 Timeliness 133
13.9.8 Non-pecuniary Interests 133
13.10 Selected Remedial Action Alternative 133
13.11 Feasibility of Achieving or Approaching Background 134

14. Findings, Conclusions, and Recommendations 135
14.1 Findings 135
14.2 Conclusions 136
14.3 Recommendations 138

References 139

Tables

Section 1:

1-1 DEP Regulatory Submittals (RTN 3-23246)

Section 2:

2-1 List of Residential and Commercial Properties within the Disposal Site

Section 3:

3-1 Commercial Property Ownership and Use (50 Tufts Street Property)
3-2 Off-Property DEP-listed Sites and Other Reported Releases within the Disposal Site
3-3 Summary of Historic Reported Releases (50 Tufts Street Property)
3-4 Summary of Aboveground and Underground Storage Tanks (50 Tufts Street Property)
3-5 Summary of Material Inventory Observed on November 18, 2004 (50 Tufts Street Property)
3-6 RCRA-SQGs within the Disposal Site

Section 4:

4-1 Soil Boring and Monitoring Well Summary
4-2 Summary of Drilling and Monitoring Well Installation Activities
4-3 Summary of Hydraulic Conductivity Testing
4-4 Summary of Shallow Soil Sampling Activities
4-5 Summary of Subsurface Soil Vapor Sampling
4-6 Summary of Groundwater Sampling Activities
4-7 Summary of Soil Physical Characteristics

4-8 Summary of Rock Core Physical Characteristics
4-9 Site-Specific Chlorinated VOCs Analyte List
4-10 Monthly Groundwater Elevations
4-11 Monitoring Well Permeability Testing Data
4-12 Summary of Subsurface Utility Measurements: Storm Drains
4-13 Summary of Subsurface Utility Measurements: Sanitary Sewers

Section 5:

5-1 Chemical Testing Results – Subsurface Soil
5-2 Chemical Testing Results – Shallow Soil
5-3 Chemical Testing Results – 95R Franklin Street Soil Samples
5-4 Chemical Testing Results – Subsurface Soil Vapor
5-5 Chemical Testing Results – Groundwater
5-6 Chemical Testing Results – Storm Drain and Sanitary Sewer Water

Section 6:

6-1 Chemical Testing Results – Indoor Air (50 Tufts Street Property)
6-2 Chemical Testing Results – Outdoor Air (50 Tufts Street Property)

Section 7:

7-1 EPEM Evaluation Property Status (Residential and Commercial Properties)
7-2a to 7-63a Chemical Testing Results – Indoor Air (Residential and Commercial Properties)
7-2b to 7-63b Chemical Testing Results – Sub-Slab Soil Vapor (Residential and Commercial Properties)
7-12c, 7-13c, 7-34c, 7-42c, 7-45c, and 7-52c Chemical Testing Results – Post-EPEM Installation Indoor Air (Residential and Commercial Properties)
7-64 Chemical Testing Results – Site-Wide Outdoor Air Samples

Section 8:

8-1 Chemical Testing Results – Outdoor Air (Capuano Center)
8-2 Chemical Testing Results – Indoor Air (Capuano Center)

Section 9:

9-1 Chemical and Physical Properties of Site-Specific Chlorinated VOCs

Section 11:

11-1a to 11-1f Risk Characterization Data – Soil (Six Exposure Areas)
11-2a to 11-2f Risk Characterization Data – Groundwater (Six Exposure Areas)
11-3a to 11-3f Risk Characterization Data – Soil Vapor (Six Exposure Areas)
11-4a to 11-4f Risk Characterization Data – Indoor Air (Six Exposure Areas)

11-5a to 11-5f Risk Characterization Data – Outdoor Air (Six Exposure Areas)
11-6a to 11-6f Exposure Point Concentrations (EPCs) (Six Exposure Areas)
11-6g Exposure Point Concentrations (EPCs) for Indoor Air at Current Commercial Buildings and Potential Future Residents

Section 13:

13-1 In Situ Technologies Identified for Initial Screening Evaluation
13-2 Ex Situ Technologies Identified for Initial Screening Evaluation
13-3 In Situ Technologies: Initial Screening Evaluation Summary
13-4 Ex Situ Technologies: Initial Screening Evaluation Summary
13-5 Detailed Evaluation Summary (Phase III Remedial Action Plan)

Figures

Executive Summary:

ES-1 Site Location Map
ES-2 Disposal Site Map and Site Boundary

Section 1:

1-1 Site Location Map
1-2 Disposal Site Map and Site Boundary

Section 2:

2-1 Site Utility Plan

Section 4:

4-1 Monitoring Well and Boring Locations
4-2 Shallow Soil Sampling Locations
4-3 Shallow Overburden Groundwater Contour Plan (March 2008)
4-4 Aerial Photograph with Regional Fill Areas and Cross-Section Locations
4-5 Generalized Regional Cross-Section A-A'
4-6 Generalized Regional Cross-Section B-B'
4-7 Cross-Section Location Plan
4-8 Cross-Section A-A'
4-9 Cross-Section B-B'
4-10 Cross-Section C-C'
4-11 Cross-Section D-D'
4-12 Cross-Section E-E'

Section 5:

5-1 Soil Boring Laboratory Testing Results
5-2 Shallow Soil Laboratory Testing Results
5-3 Subsurface Soil Vapor Laboratory Testing Results
5-4 Shallow Overburden Groundwater Laboratory Testing Results
5-5 Deep Overburden Groundwater Laboratory Testing Results
5-6 Bedrock Groundwater Laboratory Testing Results

Section 6:

6-1 50 Tufts Street Carbon Treatment System Configuration
6-2a Soil Vapor Monitoring and Extraction Points (Northern Parking Lot and 60 Tufts Street)
6-2b Soil Vapor Monitoring and Extraction Points (Southern Parking Lot)
6-3 50 Tufts Street Indoor and Outdoor Air Laboratory Testing Results

Section 7:

7-1 EPEM Study Area Progress
7-2 Schematic of Residential Sub-Slab Depressurization System
7-3 Photographs of Typical Residential Exterior Exhaust Piping for Sub-Slab Depressurization System
7-4 95R Franklin Street EPEM Option 2 Schematic
7-5 12 Morton Street EPEM Option 3 Schematic
7-6 Laboratory Testing Results – Outdoor Air Sampling

Section 8:

8-1 Capuano Center Indoor and Outdoor Air Sampling Locations 12/27/06
8-2 Capuano Center Indoor and Outdoor Air Sampling Locations 12/28/06
8-3 Capuano Center Indoor Air Sampling Locations 01/02/07
8-4 Capuano Center Indoor and Outdoor Air Sampling Locations 01/06/07
8-5 Capuano Center Indoor Air Sampling Locations 01/13/07
8-6 Capuano Center Indoor and Outdoor Air Sampling Locations 02/07/07 & 02/08/07
8-7 Capuano Center SSDS Exterior Piping Schematic
8-8 Capuano Center Trench Excavation and Wall Penetration Details
8-9 Capuano Center SSDS Blower Assembly and Piping Connections
8-10 Capuano Center Monthly Indoor and Outdoor Air Sampling Locations

Section 11:

11-1 Risk Characterization Exposure Areas

Section 13:

13-1 RAA1 – Site-wide EPEMs and MNA
13-2 RAA2 – SVE at the Property, Site-wide EPEMs, and MNA
13-3 RAA3 – DPE at and Immediately East of the Property, MNA, and Downgradient EPEMs
13-4 RAA4 – Chem-Ox at and Immediately East of the Property, MNA, and Downgradient EPEMs
13-5 RAA5 – Hydraulic Control, MNA, and Site-wide EPEMs

Appendices

A. DEP Transmittal Form (BWSC-108) and Notification Letters
B. MassGIS Map
C. Capuano Center Utility Plan
D. EDR Report (Capuano Center)
E. Miscellaneous Historic Documents
F. Boring and Monitoring Well Completion Reports
G. Hydraulic Conductivity Testing Results
H. Plume Stability Assessment
I. GPR Survey Report
J. Laboratory Data Sheets – Shallow Soil Samples (Residential and Commercial Properties and 50 Tufts Street Property) and Samples Taken Between March 31 and May 9, 2008
K. 95R Franklin Street – Soil Sampling Locations and Site Specific Risk Assessment
L. EPEM Option 2 and 3 Protocols
M. DNAPL Assessment
N. Method 3 Risk Characterization
O. RAA Cost Estimate Information

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Acronyms

µg/l	micrograms per liter
µg/m^3	micrograms per cubic meter
ACEC	Area of Critical Environmental Concern
AMEC	AMEC Earth & Environmental
AST	above ground storage tank
ATSDR	Agency for Toxic Substances and Disease Registry
AUL	Activity and Use Limitation
AWHL	Alpha Analytical Laboratories, Inc. (now Alpha Woods Hole Labs)
CAM	Compendium of Analytical Methods (Compendium of Quality Assurance and Quality Control Requirements and Performance Standards for Selected Analytical Methods)
CEP	Critical Exposure Pathway
cfm	cubic feet per minute
Chem-Ox	Chemical Oxidation
cm/s	centimeters per second
CO_2	Carbon Dioxide
COPC	Compounds of Potential Concern
CSA	Comprehensive Site Assessment
CSM	Conceptual Site Model
cy	cubic yards
DEP	Massachusetts Department of Environmental Protection
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DPE	Dual-Phase Extraction
EDR	Environmental Data Resources, Inc.
EH&E	Environmental Health & Engineering
ELCR	Excess Lifetime Cancer Risk
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentrations
EPEM	Exposure Pathway Elimination Measure
EPH	extractable petroleum hydrocarbons

ESA	Environmental Site Assessment
FRTR	Federal Remediation Technologies Roundtable
ft bgs	feet/foot below ground surface
GAC	granulated activated carbon
GC	gas chromatograph
GC/MS	Gas Chromatography/Mass Spectrometry
GEI	GEI Consultants, Inc.
gpm	gallons per minute
GPR	ground penetrating radar
HDPE	high density polyethylene liner
HI/His	Hazard Index/Hazard Indices
HP	horsepower
HVAC	heating, venting, and air conditioning system
IDW	investigation-derived waste
IES	IES, Inc.
IHE	Imminent Hazard Evaluation
IRA	Immediate Response Action
ISE	Initial Screening Evaluation
ISI	Initial Site Investigation
K_{oc}	organic carbon partition coefficient
LQG	Large Quantity Generator
LTBI	Location to be Investigated
LUST	leaking underground storage tank
MassGIS	Massachusetts Geographical Information Systems
MBCR	Massachusetts Bay Commuter Rail Company
MBTA	Massachusetts Bay Transportation Authority
MCP	Massachusetts Contingency Plan
MDL	method detection limit
MEK	methyl ethyl ketone
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MHz	megahertz
MNA	Monitored Natural Attenuation
MTBE	methyl tert-butyl ether

mV	millivolts
MWRA	Massachusetts Water Resource Authority
NAVD	North American Vertical Datum
NOR	Notice of Responsibility
NPDES	National Pollutant Discharge Elimination System
NRA	Notice of Response Action
NSR	No Significant Risk
OHM	Oil and Hazardous Material
ORP	oxidation-reduction potential
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
PCE	tetrachloroethylene (perchloroethylene)
PID	photo-ionization detector
ppbv	parts per billion by volume
ppm	parts per million
PRM	Priority Resource Map
PRP	Potentially Responsible Party
PST	PST Laboratories
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
RAA	Remedial Action Alternatives
RAO	Response Action Outcome
RAO-P	Response Action Outcome-Partial
RAP	Remedial Action Plan
RAPS	Response Action Performance Standards
RCGW	reportable concentrations groundwater
RCRA	Resource Conservation and Recovery Act
RCS	reportable concentrations for soil
REDUA	Representativeness Evaluation & Data Usability Assessment
RL	reporting limit
RMR	Remedial Monitoring Report
RNF	Release Notification Form
ROS	Remedy Operations Status
RPD	relative percentage difference

RTN	Release Tracking Number
sf	square feet/foot
SHA	Sanborn Head and Associates
SQG	Small Quantity Generator
SRM	Substantial Release Migration
SSDS	sub-slab depressurization system
SSVS	sub-slab ventilation system
SVE	soil vapor extraction
SVOCs	semivolatile organic compounds
TCA	1,1,1-trichloroethane
TCE	trichloroethylene
TOC	total organic carbon
TPH	total petroleum hydrocarbons
UCL	upper concentration limits
URF	unit risk factor
USGS	United States Geological Survey
UST	underground storage tank
UTM	Universal Transverse Mercator
UV	unit ventilator
VOC	volatile organic compound
VPH	volatile petroleum hydrocarbons

Executive Summary

On behalf of UniFirst Corporation (UniFirst) of Wilmington, Massachusetts, GEI Consultants, Inc. (GEI) prepared this Phase II Comprehensive Site Assessment (CSA) and Phase III Remedial Action Plan (RAP) for the Site located at 50 Tufts Street in Somerville, Massachusetts (the Site; Fig. ES-1). This report also includes a Method 3 Risk Characterization for the Site, prepared by AMEC Earth & Environmental (AMEC) of Westford, Massachusetts. Based on the results of assessments conducted to date, the Site includes the 50 Tufts Street property (the Property), together with portions of residential and commercial properties to the east and immediately north, south and west of the Property, and the Michael E. Capuano Early Childhood Center (Capuano Center) located at 150 Glen Street in Somerville, Massachusetts (Fig. ES-2).

In 2002, a historical release of chlorinated volatile organic compounds (VOCs) to soil and groundwater at the Property was reported to the Massachusetts Department of Environmental Protection (DEP) and assigned Release Tracking Number (RTN) 3-23246. Subsequent investigations at the Property from 2002 until 2005 identified historical releases of chlorinated VOCs to indoor air at the Property, and to groundwater and indoor air at residential properties adjacent to the Property across Tufts Street. DEP issued a Notice of Responsibility (NOR), dated November 9, 2005, to UniFirst and identified UniFirst as a potentially responsible party (PRP). The Site is classified Tier IC.

Site History

From approximately 1955 to approximately 2002, the Property was used for storage and distribution of industrial chemicals, laundry supplies, and dry cleaning supplies. Chemicals stored at and delivered to and from the Property included chlorinated solvents. These chlorinated VOCs – particularly tetrachloroethylene (PCE), trichloroethylene (TCE), and 1,1,1-trichloroethane (TCA) – have been detected in soil, soil vapor, indoor air, and groundwater on the Property and are therefore the compounds of potential concern (COPCs) for the Site.

Subsurface Investigation

Since March 2006, GEI has conducted subsurface investigations as a combination of Immediate Response Action (IRA) and Phase II activities, including:

- Installing five bedrock groundwater monitoring wells, three deep overburden monitoring wells, and 25 shallow overburden monitoring wells.

- Measuring groundwater levels monthly.
- Conducting hydraulic conductivity testing at selected monitoring wells.
- Conducting a geophysical bedrock survey of portions of the Site.
- Collecting quarterly subsurface soil vapor and groundwater samples for laboratory analysis.
- Collecting soil samples for laboratory analysis.
- Evaluating subsurface utilities.

Contaminant Distribution

The geology at the Site is composed of three units: shallow overburden (fill, silt, and till), deep overburden (till), and bedrock (argillite). The general direction of groundwater flow from the Property is to the southeast across Tufts Street towards Knowlton Street and Franklin Street.

Dissolved-phase chlorinated VOCs have been detected in groundwater in shallow and deep overburden, and bedrock beneath the Property and to the south and east of the Property. The central portion of the overburden groundwater plume is characterized by the presence of high concentrations of dissolved chlorinated VOCs, particularly PCE. The co-mingled PCE, TCE, and TCA plumes generally extend to the east and southeast of the Property, consistent with prevailing groundwater flow directions.

The shallow overburden groundwater plume is bounded approximately by Alston Street, Cross Street, Glen Street, Oliver Street, and Franklin Avenue. The Site boundary is shown in Fig. ES-2. The deep overburden and bedrock groundwater plumes extend beyond the eastern boundary of the shallow overburden plume at a very low concentration, based on the concentrations of PCE detected in groundwater collected from wells in till and bedrock.

Chlorinated VOCs generally have not been detected in soils beyond the boundaries of the Property. They have been detected in soil vapor beneath and in areas surrounding the Property, primarily in areas overlying the shallow overburden groundwater plume. Sub-slab soil vapor testing and/or indoor air testing has identified complete vapor intrusion pathways at the Property, at some residences and commercial buildings in the vicinity of the Property, and at the Capuano Center. Whether and to what extent a completed pathway may exist has proven to be highly site-specific depending on, among other things, location, soil type, foundation characteristics, and building design and condition.

Although no dense nonaqueous phase liquid (DNAPL) has been observed in monitoring wells or soils at the Site, based on multiple lines of evidence it is likely present in the overburden down to the top of bedrock (and possibly in bedrock) at the Site. The majority of

DNAPL exists as residual DNAPL, which is immobile. Any connected phase DNAPL that may be present at the Site has reached a steady state and is not migrating.

Source Mitigation

According to the Massachusetts Contingency Plan (MCP; 310 CMR 40.0000), a source of oil or hazardous material (OHM) which *is resulting or is likely to result in an increase in concentrations* of OHM in an environmental medium either by direct discharge or by intermedia transfer (310 CMR 40.1003(5)) must be eliminated or controlled in order to achieve a Permanent Solution and a Class A or B Response Action Outcome (RAO). To achieve a Temporary Solution and a Class C RAO, such an uncontrolled source must be eliminated, controlled, or mitigated to the extent feasible. By contrast, if the dissolved phase groundwater plume has reached a steady state and any DNAPLs are not migrating, as is the case here, then there is no source that is resulting in or is likely to result in an increase in concentrations of OHM in an environmental medium, and the source control criteria do not apply.

More specifically, at this Site:

- The residual DNAPL (and any connected phase DNAPL) is not migrating and exists in a stable configuration because of capillary trapping forces. The stability of the DNAPL sources is consistent with the stable groundwater concentrations in monitoring wells within the area of likely DNAPL occurrence.
- The dissolved phase groundwater plumes are at steady-state across the network of monitoring wells in both the overburden and bedrock.
- The DNAPL sources and the dissolved phase groundwater plumes are stable and are not causing an increase in concentrations of VOCs in groundwater, soil, soil vapor, or indoor air.

Mitigation of Vapor Intrusion Pathway

Sub-slab soil vapor testing and/or indoor air testing has identified complete vapor intrusion pathways at some residential and commercial buildings within the Site, and at the Capuano Center. Complete vapor intrusion pathways in the residences and the Capuano Center are considered Critical Exposure Pathways (CEP) and are presumed to require prevention, elimination, and/or mitigation to the extent feasible. GEI conducted, or is conducting, IRAs to mitigate these pathways.

To mitigate the vapor intrusion pathway in the building at the Property, GEI installed a sub-slab depressurization system (SSDS) which began operating in April 2007. Based on indoor air testing results collected since the SSDS has been operating, a condition of no Imminent

Hazard and a condition of No Significant Risk (NSR) for full-time commercial workers has been achieved for the Property building. The building at the Property is currently occupied by John's Auto Sales, a used car dealership. GEI also installed a soil vapor extraction system (SVE) at the Property to remove chlorinated VOCs from the soil above the groundwater table. The SVE system began operating in August 2007. To date, approximately 3,700 pounds (lbs) of VOCs have been removed by the SVE system.

To mitigate the vapor intrusion pathway in residences and commercial buildings, GEI is installing Exposure Pathway Elimination Measures (EPEMs). GEI conducted an evaluation of 70 residential and commercial properties at the Site. As of May 9, 2008, GEI has recommended installing EPEMs at 29 buildings: three based on sub-slab soil vapor testing results, and 26 based on indoor air testing results. To date, seven EPEMs have been installed. EPEMs have taken the form of either an SSDS or a vapor barrier and venting system, tailored to the individual characteristics of each building.

To mitigate the vapor intrusion pathway at the Capuano Center, GEI installed an SSDS, which began operating in February 2007. Since the SSDS has been operating, a condition of NSR for Capuano Center workers and students has been achieved, and the CEP has been eliminated.

Method 3 Risk Characterization

A site-specific Method 3 Risk Characterization was performed to evaluate the potential harm to human health and the environment. However, risk calculations were not performed for inhalation risks at residences or the Capuano Center because the detection of chlorinated VOCs associated with the Site in the occupied living space of a residence or the Capuano Center is a CEP requiring mitigation to the extent feasible.

The potential exposure pathways evaluated at the Site include:

- Ingestion and dermal contact with soil by a current and future commercial worker, resident, trespasser, visitor, student, teacher, railroad worker, and landscaper; and a future utility worker and construction worker.
- Ingestion and dermal contact with groundwater by a future utility worker.
- Inhalation of air in an excavation by a future utility worker and construction worker.
- Inhalation of indoor air by current and potential future occupants of commercial buildings.
- Inhalation of outdoor air by a current and future commercial worker, resident, trespasser, visitor, student, teacher, railroad worker, and landscaper.

The results of the Method 3 Risk Characterization demonstrate that potential risk from the Site to current and future receptors is at a level of NSR, assuming the indoor air exposure pathway is mitigated, where necessary to address CEPs.

Phase III Remedial Action Plan

In the Method 3 Risk Characterization, it was assumed that systems installed and proposed for installation at the Site as IRAs to mitigate indoor air exposure pathways would be implemented. A condition of NSR was demonstrated for all other potential exposure scenarios. The SSDSs and other EPEMs installed to address the indoor air exposure pathway have been shown to be effective. However, in accordance with the requirements of the MCP, GEI identified and evaluated the complete range of potential remedial technologies and remedial action alternatives that could achieve the remedial goals for the Site notwithstanding the demonstrated success of the EPEMs currently being installed. Based on this approach, and the results and assumptions documented in the Method 3 Risk Characterization, the following remedial action objectives were identified:

- Eliminate to the extent feasible potential inhalation exposure of current and future residents to chlorinated VOCs in indoor air off the Property and future residents on the Property.
- Eliminate to the extent feasible potential inhalation exposure of current and future occupants of the Capuano Center to chlorinated VOCs in indoor air.
- Where necessary, control potential inhalation exposure of the current and future commercial workers to chlorinated VOCs in indoor air off the Property and on the Property.

Following an initial screening of potential remedial technologies, GEI identified five Remedial Action Alternatives (RAAs) to address the remedial goals for the Site:

- RAA1 – Site-wide EPEMs and Monitored Natural Attenuation (MNA)
- RAA2 – SVE at the Property, Site-wide EPEMs, and MNA
- RAA3 – Dual-Phase Extraction (DPE) at and Immediately East of the Property, MNA, and Downgradient EPEMs
- RAA4 – Chemical Oxidation (Chem-Ox) at and Immediately East of the Property, MNA, and Downgradient EPEMs
- RAA5 – Hydraulic Control, MNA, and Site-wide EPEMs

GEI conducted a detailed evaluation of these five alternatives using the eight criteria specified in the MCP with consideration given to the site-specific conditions that will influence the feasibility of implementing remedial technologies. All of the RAAs rely on

EPEMs to achieve NSR by mitigating the vapor intrusion pathway into the indoor air of residences and commercial buildings. The MCP does not specify a time-frame for reaching a Permanent Solution; therefore each of the RAAs has the potential to achieve a Permanent Solution. The installation of EPEMs to mitigate the vapor intrusion pathway achieves NSR, and MNA will ultimately achieve a Permanent Solution at the Site. Once EPEMs are installed in all buildings where appropriate, the Site will operate in Remedy Operation Status (ROS).

GEI recommended RAA2 for the Site because it is timely and cost-effective, it ranked favorably compared to the other feasible alternatives based on the eight criteria specified by the MCP, and, due to the operation of the SVE system, it results in a reduction in the overall mass of contaminants at the Site, meeting the requirements of the Response Action Performance Standards (RAPS).

GEI concluded that it was not feasible to achieve background conditions at the Site because none of the RAAs could reasonably eliminate dissolved phase contaminants in bedrock groundwater or potential residual DNAPL in bedrock fractures. RAA5 – Hydraulic Control could likely be designed to capture VOC-affected bedrock groundwater, but at a substantial cost and with no reduction in risk at the Site. Therefore, GEI concluded that the cost to achieve background was disproportionate to the benefits that might accrue from such extensive remedial actions, and therefore achieving background is not feasible.

Conclusions and Recommendations

GEI recommends that EPEMs continue to be maintained where already installed at the Property, residences, commercial buildings, and the Capuano Center. Additional measures should be considered, where feasible, to convert active SSDSs to passive barrier and ventilation systems. The SVE system should continue operation in its current configuration until monitoring data indicate that residual source material in the vadose zone has been substantially removed. Confirmatory sampling that remains to be conducted under the established monitoring plan should be completed, and EPEMs should be installed at properties within the Site as and when required. Groundwater monitoring also should continue to further substantiate that the chlorinated VOCs plume (PCE, TCE, and TCA) is at steady state.

1. Introduction

GEI Consultants, Inc. prepared this Phase II Comprehensive Site Assessment (CSA) and Phase III Remedial Action Plan (RAP) on behalf of UniFirst Corporation of Wilmington, Massachusetts for the Site located at 50 Tufts Street in Somerville, Massachusetts (Site; Fig. 1-1). AMEC Earth & Environmental (AMEC) of Westford, Massachusetts prepared a Method 3 Risk Characterization for the Site, which is included in this report. This CSA documents the results of investigations conducted at the Site from June 2002 through May 2008. Based on the results of assessments conducted to date, the Site includes the 50 Tufts Street property (the Property), together with portions of properties in the neighborhoods east and immediately north, south and west of the Property, and the Michael E. Capuano Early Childhood Center (Capuano Center) located at 150 Glen Street in Somerville, Massachusetts (Fig. 1-2).

For tracking and reporting purposes, the Massachusetts Department of Environmental Protection (DEP) Release Tracking Numbers (RTNs) for this Site have been consolidated under one number, RTN 3-23246. The Site is currently classified as Tier IC. DEP issued a Tier IC permit (Permit No. W085813) to UniFirst on August 4, 2006.

1.1 Background

From approximately 1955 to approximately 2002, the Property was used for storage and distribution of industrial chemicals, laundry supplies, and dry cleaning supplies. Chemicals stored at and delivered to and from the Property included chlorinated solvents, which are volatile organic compounds (VOCs). These chlorinated VOCs – particularly tetrachloroethylene (also called perchloroethylene [PCE]), trichloroethylene (TCE), and 1,1,1-trichloroethane (TCA) – have been detected in soil, soil vapor, indoor air, and groundwater on the Property and are therefore the compounds of potential concern (COPCs) for the Site.

In 2002, a release of chlorinated VOCs to soil and groundwater at the Property was reported to the DEP and assigned RTN 3-23246. Subsequent investigations at the Property from 2002 until 2005 resulted in reports of releases of chlorinated VOCs to indoor air at the Property, and to groundwater and indoor air at residential properties adjacent to the Property across Tufts Street. On November 9, 2005, DEP issued a Notice of Responsibility (NOR) to UniFirst and identified UniFirst as a potentially responsible party (PRP).

Chlorinated VOCs have been detected in soil, groundwater (shallow and deep overburden, and bedrock), soil vapor, and indoor air at portions of the Site. The detection of chlorinated VOCs in indoor air at some buildings required the implementation of an Immediate Response

Action (IRA). IRA activities by UniFirst began at the Site in March 2006 and are ongoing. IRA activities have primarily included:

- Conducting Site-wide indoor air and subsurface sampling and testing.
- Mitigation of vapor intrusion pathways resulting in measurable concentrations of chlorinated VOCs above laboratory reporting limits (RLs) in living or working spaces in occupied residences and at the Capuano Center (a condition defined as a Critical Exposure Pathway (CEP) in the Massachusetts Contingency Plan (MCP; 310 CMR 40.0000)).
- Mitigation of vapor intrusion pathways resulting in concentrations of chlorinated VOCs measured in indoor air at commercial buildings above those that would constitute a condition of No Significant Risk (NSR), based on a Method 3 Risk Characterization.

Previous submittals by UniFirst to DEP related to RTN 3-23246 (and associated RTNs) since January 2006 are listed in Table 1-1.

1.2 Purpose

The purpose of the Phase II CSA and Method 3 Risk Characterization is to evaluate the nature and extent of the reported releases and to evaluate the potential risk to human health, public welfare, and the environment. The purpose of the Phase III RAP is to identify and evaluate remedial action alternatives which are reasonably likely to achieve a level of NSR considering the oil or hazardous material (OHM) present, media affected, and site characteristics. This Phase II CSA and Phase III RAP Report was prepared in accordance with the MCP.

1.3 Scope

Phase II CSA and IRA investigation activities were undertaken concurrently, and the results of both are considered as part of this report. These activities included:

- Reviewing previous reports and information regarding historical Property and Site uses.
- Conducting subsurface investigations consisting of soil borings; monitoring well and subsurface soil vapor monitoring point installations; soil, groundwater, and subsurface soil vapor sampling and laboratory testing; hydraulic conductivity testing; and a geophysical survey.

- Evaluating the indoor air pathway at selected residential, commercial, and educational buildings within the Site, including sub-slab soil vapor, indoor air and/or outdoor air sampling, and laboratory testing.
- Collecting water and wastewater samples from selected storm drain catch basins and sanitary sewer manholes for laboratory testing.
- Completing a Method 3 Risk Characterization to evaluate the potential risk of harm posed by the Site to human health, public safety, public welfare, and the environment.
- Identifying remedial action objectives.
- Identifying and screening potentially feasible remedial technologies.
- Conducting a detailed evaluation of Remedial Action Alternatives (RAAs) for the retained remedial technologies.
- Selecting a recommended RAA.
- Preparing a preliminary schedule for implementation of Phase IV activities.
- Preparing a Phase II and III Completion Statement.
- Preparing this Report.

1.4 Submittals

The DEP Phase II CSA and Phase III RAP transmittal forms (BWSC-108) were submitted through eDEP on July 14, 2008.

1.5 Public Participation

Local public document repositories have been established at the Somerville Central Public Library and at the City of Somerville Clerk's Office. GEI also provides electronic versions of the repository documents to the City for posting to its web site.

Prior to collecting samples for laboratory testing, GEI completed and sent property owners copies of the DEP form BWSC-123 "Notice of Environmental Sampling." Property owners were also provided copies of the laboratory testing results. Copies of the letters transmitting the BWSC-123 Forms and laboratory testing results were provided to DEP at the time they were mailed to property owners.

GEI completed and sent property owners copies of DEP form BWSC-124 "Information Notice about Immediate Response Actions" for any mitigation measures performed as an IRA, such as installation of an air purifier or an Exposure Pathway Elimination Measure (EPEM). Copies of the letters transmitting the BWSC-124 Forms were provided to DEP at the time they were mailed to property owners.

UniFirst and GEI have held a series of community meetings to inform property owners, residents, and City of Somerville officials about the Site. The agendas, attendance lists, and presentations for those meetings were submitted with the IRA Status Reports that documented activities for the relevant time period. Community meetings were held on:

- March 14, 2006
- December 21, 2006
- February 6, 2007
- February 26, 2007
- May 21, 2007
- September 17, 2007
- April 28, 2008

GEI, UniFirst, and other scientists also met and spoke with City officials, property owners, and residents on many other occasions to respond to questions and keep them apprised of ongoing response actions.

GEI sent letters to the Board of Health and Chief Municipal Officer for the City of Somerville on July 14, 2008 informing them of the preparation of this report. Copies of the transmittal forms and municipal letters are in Appendix A.

In accordance with 310 CMR 40.1403(2)(c), owners of properties have been notified that their property is located within the disposal site boundary. Copies of those letters are in Appendix A.

1.6 Conceptual Site Model

GEI developed this Conceptual Site Model (CSM) to describe release mechanisms, contaminant distribution, and potential exposure pathways associated with the Site. The CSM is based upon the investigation data documented in this Phase II, and IRA Status Reports Nos. 1 through 5. Site features associated with the CSM are shown in Fig. 1-2.

1.6.1 Site History Overview and Current Conditions

The Site is in a commercial/residential zoning district and includes the Property, together with portions of residential and commercial properties in the neighborhoods east and immediately north, south and west of the Property, and the Capuano Center (Fig. 1-2).

According to Sanborn Fire Insurance Maps (Sanborn Maps) obtained from Environmental Data Resources (EDR), from 1874 through at least 1900, residences were located on the Property. By 1933, most of the residences on the Property had been razed, and by 1950 no

structures were located on the Property. An office building and warehouse was constructed on the Property in 1955. The warehouse was expanded in 1977. The nature of the business conducted at the Property from 1955 until 2002, when operations ceased, was the storage and distribution of industrial chemicals, laundry supplies, and dry cleaning supplies. The Property is approximately 51,111 square feet (sf) and developed with an approximately 20,594-sf, one-story, masonry block building.

From 1888 until the present, the prevailing land use at the Site has been residential, but also has included commercial uses. The residences existing today are a mix of single and multi-family houses. A railroad is located between the Property and Alston Street and has been present at the Site since at least 1888. Sanborn Maps indicated that before 60 Tufts Street was converted into condominiums in approximately 1999, the property was a church (c. 1880-1933), a theater (c. 1933-1989), and a warehouse (c. 1989-1999).

The Capuano Center property was undeveloped land with a small pond located on the northern part of the property until it was developed into a playground in approximately 1950. The property remained a playground from approximately 1950 until 2001 when the City of Somerville took the playground and several abutting residences by eminent domain to build the Capuano Center. The Capuano Center is an 85,448-sf, 2-story public school located on an approximately 172,509 sf developed lot.

1.6.2 ***Potential Contaminant Sources***

Chlorinated VOCs, particularly PCE, have been measured in soil, groundwater, soil vapor, and indoor air within portions of the Site. TCE and TCA have also been measured in soil, groundwater and soil vapor at the Property. These three chlorinated VOCs are the principal COPCs at the Site. Historically, all three of these chlorinated VOCs were delivered to, stored at, handled, and distributed from the Property.

The information gathered during the Site assessment indicates that subsurface sources at the Site are not resulting in increasing concentrations of contaminants in any media throughout the available monitoring network, as defined in the MCP.

1.6.3 ***Contaminant Distribution***

1.6.3.1 Soil

COPCs found in Site soil primarily consist of PCE and TCE in soil at the Property. The highest concentrations of PCE and TCE measured in soil were located beneath the Property building slab.

At the Property, a sub-slab depressurization system (SSDS) began operating on April 30, 2007, and a soil vapor extraction (SVE) system began operating on August 22, 2007.

Through March 2008, the operation of the SSDS and SVE system had removed approximately 3,700 pounds (lbs) of VOCs from the subsurface. The operation of the SSDS and SVE system has reduced the concentrations and mass of chlorinated VOCs in the vadose soil, which are likely to continue decreasing with ongoing operation of the system.

1.6.3.2 Dense Non-aqueous Phase Liquid (DNAPL)

Chlorinated VOCs (e.g., PCE, TCE, and TCA) in the form of DNAPL have not been observed in Site monitoring wells or in groundwater or soil samples collected from the Site. However, multiple lines of evidence indicate that DNAPL is likely present in overburden down to the top of bedrock (and possibly in bedrock) at the Site. A complete assessment of DNAPL presence and distribution, prepared by Kueper (2008a), is included in this Phase II CSA Report as Appendix M.

The majority of DNAPL at the Site exists as residual DNAPL, which is immobile. Connected phase DNAPL that may be present at the Site has reached a steady state and is not migrating.

It is likely that DNAPL is present:

- At various locations beneath the entire Property building footprint.
- North of the building footprint extending beneath the paved areas.
- East of the building footprint extending across Tufts Street.
- South of the building footprint extending beneath the paved areas.
- West of the building footprint extending to the adjacent property.

1.6.3.3 Groundwater

Dissolved phase chlorinated VOCs have been measured in groundwater at the Property and in the overburden (fill, silt and till) and bedrock (argillite) to the south and east. The central portion of the overburden groundwater plume is characterized by the presence of elevated concentrations of dissolved chlorinated VOCs, particularly PCE. The co-mingled PCE, TCE, and TCA plumes generally extend to the east and southeast of the Site, consistent with prevailing groundwater flow directions.

The shallow overburden groundwater plume is bounded approximately by Alston Street, Cross Street, Glen Street, Oliver Street, and Franklin Avenue. Very low concentrations (less than approximately 300 micrograms per liter (µg/l)) of PCE have been detected in groundwater collected from wells in deep overburden and bedrock at the eastern Site boundary shown on Fig. 1-2.

1.6.3.4 Underground Utilities

Dissolved phase chlorinated VOCs have been detected in storm drains and sanitary sewers located below the water table in the southern portion of the Site along Franklin Street and Washington Street.

1.6.3.5 Vapor Intrusion and Indoor Air

In some buildings within the Site, chlorinated VOCs have been detected in indoor air samples. Where such detections coincide with elevated chlorinated VOC concentrations measured in soil vapor, they are indicative of a completed pathway from soil vapor into indoor air. Whether and to what extent a completed pathway may exist has proven to be highly site-specific, depending on, among other things, location, soil type, foundation characteristics, and building design and condition. Elevated concentrations of chlorinated VOCs detected in soil vapor samples generally coincide with elevated concentrations of chlorinated VOCs in the groundwater plume. Soil vapor concentrations of chlorinated VOCs diminish quickly beyond the edges of the overburden groundwater plume. PCE has not been detected in the indoor air at properties over the outer portions of the shallow groundwater plume.

1.6.4 Source Characterization

According to the MCP (310 CMR 40.0000), a source of OHM which *is resulting or is likely to result in an increase in concentrations* of OHM in an environmental medium either by direct discharge or by intermedia transfer (310 CMR 40.1003(5)) must be eliminated or controlled in order to achieve a Permanent Solution and a Class A or B Response Action Outcome (RAO). To achieve a Temporary Solution and a Class C RAO, such an uncontrolled source must be eliminated, controlled, or mitigated to the extent feasible. By contrast, if the dissolved phase groundwater plume has reached a steady state and any DNAPLs are not migrating, as is the case here, then there is no source that is resulting in or is likely to result in an increase in concentrations of OHM in an environmental medium, and the source control criteria do not apply.

More specifically, at this Site:

- The residual DNAPL (and any connected phase DNAPL) is not migrating and exists in a stable configuration because of capillary trapping forces. The stability of the DNAPL sources is consistent with the stable groundwater concentrations in monitoring wells within the area of likely DNAPL occurrence.
- The dissolved phase groundwater plumes are at steady-state across the network of monitoring wells in both the overburden and bedrock.

- The DNAPL sources and the dissolved phase groundwater plumes are stable and are not causing an increase in concentrations of VOCs in groundwater, soil, soil vapor, or indoor air.

1.6.5 Receptors and Potential Exposure Pathways

Potential exposure pathways at the Site based on distribution of Site contaminants include:

- Ingestion and dermal contact with soil by a current and future commercial worker, resident, trespasser, visitor, student, teacher, railroad worker, and landscaper; and a future utility worker and construction worker.
- Ingestion and dermal contact with groundwater by a future utility worker.
- Inhalation of air in an excavation by a future utility worker and construction worker.
- Inhalation of indoor air by current and potential future occupants of commercial buildings.
- Inhalation of outdoor air by a current and future commercial worker, resident, trespasser, visitor, student, teacher, railroad worker, and landscaper.

2. Disposal Site Information [310 CMR 40.0835(4)(a)(b)]

Information presented in this section references state and federal databases and file reviews, Unites States Geological Survey (USGS) publications, municipal file reviews, and GEI's Phase I Initial Site Investigation (Phase I ISI) and Tier Classification Report, dated June 16, 2006.

2.1 Site Location and Description

The Site is in a commercial/residential zoning district and includes the Property, together with portions of residential and commercial properties in the neighborhoods east and immediately north, south and west of the Property, and the Capuano Center (Fig. 1-2). The Universal Transverse Mercator (UTM) coordinates of the Property are 4,694,322 N and 328,049 E.

2.1.1 The Property Location and Description

The Property is approximately 51,111 sf and developed with an approximately 20,594-sf, one-story, masonry block building. The majority of the Property building is warehouse space, and a small portion is office space.

The eastern side of the building abuts the sidewalk and then Tufts Street, and on the western side of the building is a narrow strip of vegetation and then railroad tracks. Immediately north and south of the building is paved parking. Further south of the building is a grassed hill that slopes towards Washington Street. Access to the Property is restricted by a 6-foot-high chain-link fence.

The building was constructed in two stages. The approximately 8,400-sf northern portion of the building was constructed in 1955. An approximately 12,200-sf addition was constructed in 1977. The building is slab on grade construction. Approximately 3,300 sf of the building was constructed at natural grade with the remainder of the building constructed on approximately 4 feet of fill.

2.1.2 Residential and Commercial Properties Location and Description

In addition to the Property, the Site includes a several block area of residential and commercial properties which are listed in Table 2-1 and shown in Fig. 1-2. The residences are single and multi-family houses. Commercial properties located within the Site include:

- A costume and flag manufacturer (30-40 Alston Street).
- Four restaurants and bars (142 Cross Street, 97 Washington Street, 113 Washington Street, and 120 Washington Street).
- A catering company (121 Washington Street).
- Veterans of Foreign Wars Post (163 Glen Street).
- A retail strip mall (30-32 Washington Street).
- Two automobile repair garages (91 and 103 Washington Street).
- A church (85 Washington Street).
- An ambulance office and garage (137 Washington Street).

The list above does not include home-based businesses and is not considered an exhaustive list of commercial properties within the Site. Residences at the Site include single family homes, condominiums, apartments, and other multi-family dwellings.

Sanborn Maps indicate that before 60 Tufts Street was converted into condominiums in approximately 1999, the property was a church (c. 1880-1933), a theater (c. 1933-1989), and a warehouse (c. 1989-1999).

Land parcels without occupiable structures include:

- 10 Alston Street and 34 Knowlton Street (structures are garages only).
- Tax Assessor's Map 93, block A, lot 13 (Glen Street).
- Tax Assessor's Map 104, block A, lots 5, 5A, 37, 38, and 65 (Franklin Street).
- Tax Assessor's Map 104, block E, lot 8 (Franklin Street).

2.1.3 Capuano Center Location and Description

The Site also includes the Capuano Center located at 150 Glen Street. The Capuano Center is an 85,448-sf, 2-story public school located on an approximately 172,509-sf developed lot. In addition to the Capuano Center building, the lot contains a playground, soccer field, basketball court, and paved parking areas. Three community gardens are located on the Capuano Center property on the corner of Glen and Oliver Streets, and on the corner of Franklin Street and Palmer Avenue.

The southern side of the building abuts a paved driveway and parking areas. The eastern side of the building abuts a sidewalk, and then Franklin Street. There is also a small parking area north of the basketball court on the eastern edge of the property. The northern and western sides of the building are abutted by a playing field and a playground, respectively. Access to the building is from Glen Street to the west and Franklin Street to the east.

2.2 Disposal Site Map

A Site Plan, including the locations of borings and monitoring wells and the Site boundary, is presented in Fig. 1-2. The Site boundary is based on the concentration of chlorinated VOCs, particularly PCE, detected in groundwater. Screening data collected by DEP at the Capuano Center was used to locate monitoring wells from which groundwater samples were collected for laboratory analysis. As required by the MCP (310 CMR 40.1056(1)(j)), laboratory data which is compliant with DEP's Compendium of Quality Assurance and Quality Control Requirements and Performance Standards for Selected Analytical Methods (CAM) was then used to establish the Site Boundary.

In the shallow overburden wells, the concentration of PCE at the Site boundary is estimated to be less than 1 μg/l, which is the laboratory RL. The deep overburden and bedrock groundwater plumes extend beyond the eastern boundary of the shallow overburden plume at a very low concentration, based on the concentrations of PCE detected in groundwater collected from wells in till and bedrock. In addition, the Site boundary has been appropriately approximated since the concentrations of PCE in these wells show substantial attenuation from the center of the plume.

2.3 Site Vicinity

The Site is located in a residential and commercial neighborhood (Fig. 1-2). The Site is abutted by the following:

- Residences and commercial properties, Alston Street, and Cross Street to the west.
- Franklin Avenue to the east.
- Selected residences, Dell Street, Glen Street, and Franklin Street to the north.
- Washington Street, New Washington Street, and commercial and residential properties to the south.

2.3.1 Nearby Chlorinated VOC DEP-listed Releases

Based on our review of state and federal databases, GEI identified three sites within 0.25 miles of the Site that are associated with releases of chlorinated VOCs. GEI performed a DEP file review on December 3, 2007 for these sites and the results of the review are summarized below.

2.3.1.1 Release Tracking Numbers 3-2665 and 3-2672

In May and June 1989, on behalf of Tauro Realty Co. (Tauro), IES, Inc. (IES) of Somerville, Massachusetts, conducted Environmental Site Assessments (ESAs) of two properties located

in Somerville, Massachusetts: 308 McGrath Highway and 182 Washington Street (located southwest of the Site). As part of the ESAs, IES installed monitoring wells at both properties and collected soil samples. During field screening, IES detected VOCs in soil samples. Chlorinated VOCs including PCE, TCE, 1,1,2,2-tetrachloroethane, and cis-1,2-dichloroethylene were detected at levels above laboratory RLs in groundwater samples collected from the property monitoring wells. IES also detected total petroleum hydrocarbons (TPH) at both properties.

IES attributed the detections of chlorinated VOCs in groundwater to an off-site source, and attributed the TPH detections to the historic use of the properties as a gas station (182 Washington Street), and a machine shop and various automobile repair businesses (308 McGrath Highway).

On March 5, 1990, DEP initially notified Tauro that the properties had been classified as Locations to Be Investigated (LTBI) and assigned RTN 3-2665 to the release at 306-308 McGrath Highway, and RTN 3-2673 to the release at 182 Washington Street. On January 8, 1997 DEP notified Tauro that the Sites had been listed as Tier IB (Tier ID) sites for failure to investigate and assess the release of chlorinated VOCs at the properties. Both sites are currently listed as default Tier ID sites.

On June 14, 2007, Tauro submitted an informal letter with the address of a former dry cleaner (Embassy Cleaners located at 169-179 Washington Street) to DEP and suggested that the dry cleaner was the source of the VOCs at 306-308 McGrath Highway and 182 Washington Street.

2.3.1.2 Release Tracking Number 3-27087

In August 2007, DEP initiated an investigation of a former dry cleaning business located at 163 (previously 179) Washington Street in Somerville, Massachusetts as a result of the release of chlorinated VOCs to groundwater at two nearby properties: 306-308 McGrath Highway (RTN 3-2665) and 182 Washington Street (RTN 3-2673). DEP collected groundwater samples from 1-inch diameter well points and detected PCE at concentrations ranging from 100 to 1,900 µg/l from a downgradient well point on nearby Mansfield Street and at a concentration of 9,300 µg/l from a well point at the subject property. DEP also sampled indoor air at the property and detected 90.9 micrograms per cubic meter (µg/m^3) of PCE in the basement, and 87.6 µg/m^3 on the first floor of a photography shop at the property, which indicated an Imminent Hazard Condition. DEP assigned RTN 3-27087 to the release of PCE to groundwater and the Imminent Hazard Condition in indoor air. The building contains a photography shop and additional retail stores.

Based on inferred groundwater flow directions, the contamination associated with RTN 3-27087 is not believed to have impacted the area within the Site (RTN 3-23246).

As a result of its investigation, DEP issued a NOR and a Notice of Need to Conduct an IRA on September 11, 2007, to the current owners of 163 Washington Street, Ms. Antonette Spinucci and Mr. Leonard Dicicco.

On May 5, 2008, GEI reviewed additional documents for 179 Washington Street, (RTN 3-27087) at DEP. On November 23, 2007, ENPRO Services Inc. of Newburyport Massachusetts, on behalf of DEP, installed two carbon air-purifying systems in the basement and first floor of the 179 Washington Street property to temporarily mitigate the indoor air until a permanent SSDS is installed.

Since issuing the NOR and initiating IRAs at the 179 Washington Street property, DEP has installed and sampled 21 additional temporary groundwater monitoring well points near the property. Based on groundwater elevations measured from these well points, groundwater appears to be flowing to the south from the 179 Washington Street property toward Mansfield Street and McGrath Highway. Groundwater does not appear to be flowing east toward the Property. After evaluating groundwater flow direction, DEP conducted sub-slab soil vapor and indoor air sampling in several downgradient residential and commercial properties on Mansfield Street and McGrath Highway. Results of soil vapor and indoor air sampling suggest that CEPs currently exist in at least two downgradient properties. Shaw Environmental and Infrastructure (Shaw) of Andover, Massachusetts is currently undertaking IRAs on behalf of DEP at the site.

2.4 Natural Resource Areas and Surrounding Land Use

Based on background information and the Massachusetts Geographic Information System (MassGIS) Natural Resources Map for the Site (Appendix B) dated April 28, 2008 environmental setting and potential sensitive receptors of the Site and its vicinity include:

- Residential Population: Because the Site is an urban area, it is estimated that greater than 1,000 residents live within 0.5-mile of the Site.
- On-Site Workers: Residential and other commercial properties within the Site are occupied.
- Institutions: The Michael E. Capuano Early Childhood Center is approximately 350 feet east of the Property, located within the Site.
- Drinking Water Supplies: There are no known drinking water supplies (Zone II areas, Interim Wellhead Protection Areas, Zone A areas, Potentially Productive Aquifers, or private wells) or Sole Source Aquifers within 500 feet of the Site.
- Surface Waters and Wetlands: There are no known wetlands, vernal pools, ponds, lakes, or reservoirs within 500 feet of the Site. The nearest surface water is the Mystic River, located approximately 0.9 mile northeast of the Site.

- Fish Habitat: There is no known fish habitat within 500 feet of the Site.
- Area of Critical Environmental Concern (ACEC): According to the MassGIS map, the Site is not located in an ACEC.
- Threatened or Endangered Species: According to the MassGIS map, there are no Natural Heritage and Endangered Species Program Estimated Habitats for Rare Wetlands Wildlife within 500 feet of the Site. According to the Massachusetts Natural Heritage Atlas, there are no priority habitats of rare species, estimated habitats of rare wildlife, or certified vernal pools within 500 feet of the Site.
- Protected Open Space: According to the MassGIS map, the Capuano Center, located approximately 350 feet east of the Property, is a Protected Open Space. There are no other known Protected Open Spaces within 500 feet of the Site.

2.5 Current Site Utilities

Based on a review of readily available subsurface utility plans, underground utilities at the Site include water, sewer, storm drain, gas, electric, communication, and fire alarm box electrical lines. The approximate locations of the known utilities are shown in Fig. 2-1.

2.5.1 The Property Utilities

A sewer line runs down the center of Tufts Street. A water line runs down Tufts Street on the west side of the sewer line. Gas and electric lines run down the northeastern side of Tufts Street. There are several service connections from the main sewer line to the Property. Gas and electric service connections are located on the northeast corner of the Property building. Water lines connect to two hydrants on the Property and one near the intersection of Knowlton and Tufts Streets.

The Tufts Street sewer line drops in elevation from the northwest end of Tufts Street to the southeast end at the intersection with Washington Street.

Four storm water catch basins located beneath the railroad bridge on Washington Street are connected to a pump lift station operated by the Massachusetts Bay Commuter Rail Company (MBCR).

2.5.2 Residential and Commercial Properties Utilities

Sewer lines typically run down the center of each street within the Site. Gas and water lines are located on either side of the sewer line. Electric lines run underground on Tufts Street and a small portion of Glen Street near the fire alarm box electrical lines. Available service connections to residences and commercial properties are shown in Fig. 2-1.

2.5.3 Capuano Center Utilities

A site utility plan dated August 10, 2001 for the Capuano Center, prepared by HMFH Architects, is in Appendix C. The plan shows a sanitary sewer line and a combined sewer line crossing the center of the property from near a parking area on Glen Street to Franklin Street near the basketball courts. Additional combined sewer lines are located to the south of the Capuano Center building and underneath the basketball courts. Storm drains discharge to combined sewers on Franklin and Glen Streets, and to two underground detention structures located beneath the parking lot on the south side of the building and the playing field on the north side of the building. The sanitary sewer service connection is located on the northwest side of the Capuano Center.

Gas, water, and fire protection service connections are located on the southwest corner of the building. The Capuano Center is serviced by overhead electric lines from Glen Street to the east.

3. Disposal Site History [310 CMR 40.0835(4)(c)]

Information presented in this section references GEI's Phase I Report and IRA submittals; municipal, state, and federal databases and file reviews; and GEI field observations.

3.1 Ownership and Operation History of the Site

3.1.1 The Property Ownership and Operation History

The ownership and operations history of the Property is based on historic Sanborn Maps obtained from EDR for the years 1888, 1900, 1933, 1950, 1989, and 1991; City of Somerville Atlases dated 1874 and 1884; and public documents such as deeds and purchase agreements relative to the sale of the Property. A summary of Property ownership and operations is in Table 3-1. A copy of the current EDR report is in Appendix D, a map of the Site vicinity dated 1872 and Sanborn Maps are in Appendix E.

From 1874 through at least 1900, residences were located on the Property. By 1933, most of the residences on the Property had been razed, and by 1950 no structures were located on the Property.

According to available public records, on December 7, 1950, Superior Products Co., Inc., hereinafter called "Superior Products Co., Inc. (1950)," with a business address of 148 Pearl Street in Somerville, Massachusetts, was incorporated. The nature of the business was to manufacture, buy, sell, and deal in industrial chemicals, laundry supplies, and dry cleaning supplies. According to an affidavit made by Mr. Frank Wahlen, his father, Mr. Walter Wahlen, who was one of the incorporators of Superior Products Co., Inc. (1950), purchased the Property on December 6, 1954, and shortly thereafter, constructed an office building and warehouse. He then leased the building to Superior Products Co., Inc. (1950).

On September 30, 1976, the assets of Superior Products Co., Inc. (1950) were sold to Superior Products & Equipment Co., Inc. (a newly formed corporation, hereinafter called Superior Products & Equipment Co., Inc. (1976)). Superior Products & Equipment Co., Inc. (1976) was a wholly owned subsidiary of Interstate Uniform Services Corporation, now known as UniFirst Corporation. Although the transactional documents relating to the September 30, 1976 acquisition refer to Superior Products Co, Inc., the business was carried out under the name SPEC, and there is a conforming deed dated July 13, 1987 acknowledging that SPEC was the Property owner that conveyed it to 50 Tufts Street, Inc.

On September 27, 1985, the John Danais Co., Inc. of Manchester, New Hampshire, purchased the assets, including inventory, of Superior Products & Equipment Co., Inc.

(1976). As of that date, the John Danais Co., Inc. also leased the building and land at the Property.

On March 30, 1987, John Danais of the John Danais Co., Inc. formed 50 Tufts Street, Inc., with a principal office at the Property. On May 21, 1987, 50 Tufts Street, Inc. purchased the Property from Superior Products & Equipment Co., Inc. (1976). John Danais Co., Inc. continued to occupy the Property and operate as a distributor of laundry and dry cleaning supplies until approximately August 2002, when John Danais Co., Inc. ceased operations at the Property.

A Certificate of Use and/or Occupancy dated July 10, 1990 was issued for the Property by the City of Somerville Building Inspection Department for office and storage space use for a moving and storage company. Fire Department records indicate that in 1993 a furniture moving company occupied space in the warehouse. Some time prior to August 2002, Father & Son Moving and Storage (Father & Son) entered into a lease with 50 Tufts Street, Inc. to lease parking space and office space in the northern portion of the Property building. At the time Father & Son entered into the lease, the John Danais Co., Inc. was still operating a laundry supply business in the southern portion of the Property building. On October 4, 2002, John Danais Co., Inc. filed for bankruptcy. By the end of December 2004, Father & Son vacated the Property building.

On May 10, 2005, Atlantic National Trust, LLC, holder of a mortgage on the Property, took title to the Property in the name of Somerville Two LLC (Somerville Two). Somerville Two is the current owner of the Property.

The Property is currently leased and occupied by John's Auto Sales of Somerville, Massachusetts and is used as a storage warehouse for automobiles. John's Auto Sales began occupancy of the building in March 2008.

3.1.1.1 Potentially Responsible Parties

In an NOR dated October 29, 2003, issued to 50 Tufts Street, Inc., DEP identified 50 Tufts Street, Inc. as a PRP. This NOR was issued in response to a Release Notification Form (RNF) submitted to DEP on behalf of 50 Tufts Street, Inc. for the presence of chlorinated VOCs in soil and groundwater at the Property in concentrations above the applicable reportable concentrations. DEP issued an NOR; Notice of Need to Conduct IRA; Designation of Interim Deadlines, dated November 5, 2004, to 50 Tufts Street, Inc. due to the concentrations of chlorinated VOCs detected in groundwater less than 15 feet below ground surface (ft bgs) and within 30 feet of an occupied residential structure. 50 Tufts Street, Inc. owned the Property at the time. 50 Tufts Street, Inc. filed with the DEP for Financial Inability Status; however, the DEP deemed the application incomplete.

In an NOR dated November 16, 2004, issued to the John Danais Company, DEP identified the John Danais Company as a PRP. The NOR was issued in response to the oral notification of the presence of chlorinated VOCs in indoor air at the Property.

On June 9, 2005, DEP issued a Notice of Need to Conduct IRA to Somerville Two. DEP's Notice identified Somerville Two as an Other Party because it had acquired title to the Property through foreclosure proceedings instituted by Atlantic National Trust, LLC.

In an NOR dated November 9, 2005, DEP identified UniFirst as a PRP.

3.1.2 Residential and Commercial Property Ownership and Operation

The ownership and operations history of the residential and commercial properties that may have used significant quantities of OHM that are located within portions of the Site is based on historic Sanborn Maps obtained from EDR for the years 1888, 1900, 1933, 1950, 1989, and 1991 (Appendix D) and additional background information.

From 1888 until the present, land use at the Site, excluding the Property and Capuano Center, has been primarily residential with some commercial uses. Knowlton and Morton Streets were undeveloped land until approximately 1900. Occasional industrial properties were present at the Site from at least 1888 until approximately 1900, including:

- A metal works facility (Somerville Spike Works) in the vicinity of 85 Washington Street.
- An iron foundry (S.B. Locke and Co.) on the corner of Washington and Myrtle Street.
- Two vinegar factories; one on Myrtle Street, and one on Washington Street near the current location of the Cobble Hill Apartments.
- An un-named laundry supplies storage facility located at 40 Alston Street from approximately 1955 until approximately 1989.

The railroad between the Property and Alston Street has been present at the Site since at least 1888.

3.1.3 Capuano Center Ownership and Operation

A utility plan from approximately 1872, obtained from the City of Somerville's Engineering Department, shows the Capuano Center property as undeveloped land with a small pond located on the northern part of the property near Oliver and Franklin Streets (Appendix E). Sanborn maps show the Capuano Center as undeveloped land from at least 1888 until approximately 1950, when it was converted to a playground. The pond from the City utility map is not shown on the Sanborn maps. It is unclear when the pond was filled. The property

remained a playground from approximately 1950 until 2001 when the City of Somerville took the playground and several abutting residences on Palmer Court, Franklin Street, and Oliver Street by eminent domain to build the Capuano Center.

3.2 Site Release History

RTNs have been assigned to four reported releases of chlorinated VOCs associated with the Site: 3-23246, 3-24358, 3-24376, and 3-26114. RTNs 2-24358 and 3-24376 were linked to RTN 3-23246 at the time of GEI's Phase I Initial Site Investigation and Tier Classification. RTN 3-26114 was linked to RTN 3-23246 via BWSC-107 "Tier Classification Transmittal Form" submitted through eDEP on July 17, 2007.

There have been several reported releases of OHM at commercial properties within the Site that do not involve chlorinated VOCs. These spills and releases are summarized in Table 3-2 and details are provided in the EDR report in Appendix D. These DEP-listed release sites have achieved regulatory closure.

3.2.1 The Property

A summary of historic releases at the Property are summarized in Table 3-3.

3.2.1.1 Release Tracking Number 3-23246

In 2002, Mr. Francis Margaglione, a prospective purchaser of the Property, engaged Sanborn, Head & Associates (SHA) of Westford, Massachusetts to conduct an environmental due diligence investigation. SHA performed a subsurface exploration program including the collection of soil and groundwater samples for laboratory analyses. SHA measured PCE, TCE and other chlorinated VOCs in soil and groundwater samples in concentrations greater than the applicable MCP reportable concentrations for soil (RCS) category RCS1 and groundwater (RCGW) category RCGW2.

Mr. Margaglione provided the data to 50 Tufts Street, Inc., the Property owner at the time. On October 3, 2003, on behalf of 50 Tufts Street, Inc., Mr. Craig Campbell notified DEP of a release of PCE and other hazardous materials in excess of the applicable reportable concentrations. DEP issued an NOR to 50 Tufts Street, Inc. and assigned RTN 3-23246 to the release.

3.2.1.2 Release Tracking Number 3-24376

In August 2004, on behalf of Atlantic National Trust, LLC (the mortgagee of the Property), GeoInsight, Inc. (GeoInsight) of Westford, Massachusetts installed four groundwater monitoring wells along the east side of Tufts Street, approximately 30 to 40 feet from the Property. PCE, TCE, and TCA were detected in groundwater collected from each of the

wells. In two of the wells located within 30 feet of residences, the concentrations of total VOCs were greater than 5 milligrams per liter (mg/L), triggering an MCP 72-hour reporting requirement.

On November 5, 2004, DEP issued an NOR to 50 Tufts Street, Inc. to conduct an IRA to evaluate the potential for a CEP and/or a condition of Substantial Release Migration (SRM) due to the presence of VOCs in concentrations greater than 5 mg/L in the groundwater within 30 feet of occupied residences. DEP assigned RTN 3-24376 to this reported release condition.

3.2.1.3 Release Tracking Number 3-24358

On September 23, 2004, on behalf of Father & Son, a building tenant, SHA collected a sample of indoor air from the office portion of the Property building and submitted the sample for laboratory analysis of VOCs. PCE (6290 $\mu g/m^3$), TCE (234 $\mu g/m^3$), and related chlorinated VOCs were detected at elevated concentrations in the air sample. Based on the air testing results, SHA concluded there was a potential for an Imminent Hazard to a 40-hours per week commercial worker when evaluated over a period of five years. SHA identified the John Danais Company as the owner of the Property.

On behalf of the building tenant, SHA reported the Imminent Hazard to DEP on October 22, 2004. DEP assigned RTN 3-24358 to this reported release condition. On November 16, 2004, DEP issued an NOR to the John Danais Company.

3.2.1.4 Historic Releases

A DEP Release Log Form Attachment (BWSC-102B), dated March 24, 2005, documents a discussion between Mr. Richard Papa, the owner and resident of 27 Tufts Street, and Ms. Irene Dale of DEP. Mr. Papa reportedly worked at Superior Products & Equipment Co., Inc. (1976) from 1978 until 1980. Mr. Papa recalled spills occurring in connection with a tank fill pipe used to fill a tank inside the building with PCE. Mr. Papa also recalled a spill of approximately 50 to 60 gallons of PCE in 1979. The location of the spill was not identified. Other historic spills have been reported as occurring at various times during the facility's operations.

3.2.2 Residences and Commercial Properties Release History

3.2.2.1 Release Tracking Number 3-26114

As part of investigations associated with the Property, GEI collected quarterly indoor air samples in March, June, and July, October, and December 2006, from residences at 9, 11/13, 19, 23, 25, and 27 Tufts Street. PCE concentrations in samples from 23 and 27 Tufts Street were significantly higher than previously measured. Based on these concentrations and an

initial Imminent Hazard Evaluation (IHE), UniFirst reported to DEP on August 1, 2006 the potential for an Imminent Hazard at 23 Tufts Street. DEP assigned RTN 3-26114 to the reported release condition.

GEI collected additional air samples at 23 and 27 Tufts Street on August 3, 2006, to confirm the original test results and further evaluate the potential for an Imminent Hazard. PCE concentrations in samples collected in the August 2006 samples were significantly lower than those collected in June 2006. Based on the additional data and an updated IHE, UniFirst retracted the Imminent Hazard Notification in a letter dated September 21, 2006. In their letter of October 11, 2006, DEP disputed the retraction and required the submittal of an IRA Plan.

GEI submitted an IRA Plan on April 2, 2007, and IRA Plan Modification No. 1 on April 12, 2007 and proposed to expand the indoor air investigation area to include additional residential and commercial properties on Alston, Franklin, Knowlton, Morton, Dell, Tufts, and Glen Streets. For administrative purposes, DEP incorporated the off-Property indoor air investigation locations under RTN 3-26114.

3.2.3 Capuano Center Release History

3.2.3.1 Release Tracking Number 3-26114

Beginning in December 2006, GEI conducted indoor air sampling at the Capuano Center as part of the ongoing investigations associated with the Site. PCE was detected in indoor air samples in three classrooms and their associated resource rooms. DEP incorporated the Capuano Center under RTN 3-26114.

3.3 Site OHM Use and Storage History

3.3.1 The Property OHM Use and Storage History

GEI obtained information from the Somerville Fire Department regarding underground storage tanks (USTs) and above ground storage tanks (ASTs) at the Property. A summary of ASTs and USTs is in Table 3-4. According to Fire Department records, materials stored and/or used at the Property included PCE, TCE, TCA, assorted dry cleaning solvents, bleaching powder, oxidizers, corrosives, and diesel.

According to information obtained from Mr. Danais and others, the John Danais Company stored, handled, and transported dry cleaning and laundry supplies at the Property. Materials stored at the Property by the John Danais Company included PCE, detergents, alkaloids, and bleaches. For a period of time, PCE was delivered to the Property via tanker trucks and offloaded to an AST at the southern end of the building. PCE was then redistributed to buyers by truck. Mr. Danais indicated that the John Danais Company received, stored, and

shipped approximately 3,000 gallons of PCE per week. Some time during the time the John Danais Company operated at the Property, deliveries of PCE by tanker truck ceased and PCE was delivered in 15-gallon drums. The other materials, detergents, alkaloids, and bleaches, were delivered in drums, barrels or bags. According to Mr. Danais, materials were delivered to one of six truck bays at the south end of the Property building.

On November 18, 2004, GEI personnel visited the Property to observe property conditions and inventory the materials, containers, drums, and ASTs in the building. A summary of the materials and containers observed by GEI on November 18, 2004 is in Table 3-5.

After taking title to the Property, Somerville Two arranged for the removal of the stored PCE, detergents, oily liquids, and corrosives from the Site. They also arranged for the removal of the remaining ASTs. Materials were transported off-site between August 22, 2005 and October 7, 2005. A list of the materials removed and their quantities are in Table 3-5. Copies of manifests and bills of lading were submitted to DEP in GEI's Phase I report, dated June 16, 2006.

During a visit to the Property by GEI on December 7, 2005, GEI observed that most of the chemical containers (ASTs, drums, etc.) had been removed from the building since GEI's prior visit to the Property in November 2004. However, several small chemical containers and chemical piping and hoses were still observed in the building. Several brightly colored metal pipes were observed on the walls along the northern and northwestern end of the warehouse. Each of the pipes was approximately 2 to 3 inches in diameter and ran along the walls. The ends of the pipes ran through the wall of the warehouse to the exterior of the building. These metal pipes were presumably used to move chemicals from bulk storage in the warehouse to the transport vehicle(s). These metal pipes were labeled "METHYLENE CHLORIDE," "PERCHLOROETHYLENE-SVC," "CHLOROTHENE-VC," and "NEU-TRI."

On June 21, 2007, GEI engaged Norfolk Construction (Norfolk) to remove overhead piping that contained residual PCE. GEI screened overhead pipes with a photo-ionization detector (PID) and connected a vacuum to the open pipe ends to confirm the piping was empty. Approximately 2 gallons of liquid were removed, stored in a 55-gallon drum, and transported offsite under a hazardous waste manifest. Laboratory testing of the liquid obtained from the piping indicated that it was PCE. Approximately 50 feet of 1.5 inch-diameter piping, and 60 feet of 2-inch-diameter piping, were removed from the building, cut into 6-foot sections, and transported offsite as scrap metal to Middleboro Recycling, Inc. in North Middleboro, Massachusetts.

3.3.2 Residential and Commercial Properties OHM Use and Storage History

Generally residential and commercial property owners within the Site do not store chemicals in ASTs, USTs, drums, or otherwise on their properties. (Exceptions are discussed in Section 3.4.2.). However, during indoor air sampling events, GEI personnel noted that most residential and commercial properties store household cleaning products, detergents, and other materials that could potentially contain chlorinated VOCs. Residents asked that GEI not undertake a formal inventory or remove such materials prior to sampling. Chemical products in plain view were documented during sampling events on the indoor air sampling checklists previously submitted to DEP in IRA Status Reports No. 1 through 5, but were left in place.

Automotive repair facilities located at 91 and 103 Washington Street are known to store and use or are likely to store and use solvents in their daily operations.

GEI personnel observed containers labeled as PCE stored in the basement of the residence at 9 Knowlton Street. The volume of these containers with PCE labels was estimated to be approximately 25 gallons and the containers were observed to be at least partially filled.

GEI observed an apparently empty 30-gallon drum labeled "PERCHLOROETHYLENE" in the basement of 15 Morton Street during indoor air sampling on February 27, 2008. The drum was not removed prior to sampling.

A laundry and dry cleaner is located in the Cobble Hill Strip Mall at 82 Washington Street; however, according to conversations between GEI and the store operator, no dry-cleaning is currently performed on the premises.

3.3.3 Capuano Center OHM Use and Storage History

The Capuano Center does not have ASTs or USTs on its premises. The Capuano Center maintains a small supply of cleaning and maintenance products. The initial pre-sampling survey and indoor air sampling checklists for the Capuano Center are in IRA Status Report No. 3 and IRA Status Report No. 1 submitted to DEP in May 2007.

3.4 Waste Management

3.4.1 The Property

3.4.1.1 RCRA Small Quantity Generator Status

A former Property owner, Superior Products and & Equipment, Co. was listed in the EDR report as a Resource Conservation and Recovery Act (RCRA) Small Quantity Generator (SQG). Superior Products & Equipment, Co. was cited with a RCRA violation on

November 2, 1984. The EDR report identifies the area of violation as "Generator-All Requirements (Oversight)." Compliance was reportedly achieved on April 3, 1985. There is no other known historical information suggesting that Superior Products & Equipment, Co. generated or stored hazardous waste, or that it in fact was an SQG. There are no other known records or reports of historical waste management at the Property prior to implementation of response actions on the Property.

3.4.1.2 RCRA-Large Quantity Generator Status

As described in Section 3.3.1, Somerville Two removed large quantities of materials from the Property building in 2005. There is no known record that indicates Somerville Two applied for Large Quantity Generator (LQG) status.

UniFirst operates SSDS and SVE systems at the Property. Soil vapor extracted by the SSDS and SVE systems is collected and treated by activated carbon prior to discharge to the ambient air. Because UniFirst generated more than 2,200 lbs of waste, mostly "spent" carbon from the off-gas control, on July 11, 2008, it applied for RCRA LQG status. In addition to the "spent carbon," waste generated at the Site includes investigation and mitigation derived waste (IDW) (e.g. soil cuttings and groundwater). RCRA waste is not stored on-site; instead, waste is accumulated at the point of generation and transported off-site on the same day. To date, approximately 16,000 lbs of "spent" activated carbon have been transported off-site. Copies of hazardous waste manifests are in previously submitted IRA Status Reports No. 1 through 5.

3.4.2 Residential and Commercial Properties

There are four RCRA SQG properties within the Site. However, none of these properties reportedly store chlorinated VOCs as part of their operations, and no compliance violations have been reported for these properties. A list of these SQGs is in Table 3-6.

3.5 Environmental Permits and Compliance

3.5.1 The Property

According to a document obtained from the City of Somerville's Fire Prevention Office, yearly maintenance permits were issued to John Danais Company for a 14,000-gallon PCE AST; two 5,000-gallon ASTs; the above ground storage of assorted dry cleaning solvents, bleaching powder, and other solvents; five 33-pound propane tanks; and a warehouse containing 55-gallon drums of oxidizers and corrosives.

A permit was issued by the Fire Department on September 1, 2005 for the removal of the 14,000-gallon AST. Fire Department records also indicate the removal of a 5,000-gallon diesel UST on August 19, 1987; and the removal of four ASTs (one 10,000-gallon; one

1,500-gallon; and two 2,500-gallon) on November 30, 1990. The contents of the ASTs were not specified.

3.5.2 Residential and Commercial Properties

According to the EDR report, there are no commercial or residential properties within the Site that have active ASTs or USTs on their premises. However, some buildings within the Site boundary are likely to have ASTs associated with heating oil on their premises. GEI identified one property within the Site boundary, 91 Washington Street, which had a leaking underground storage tank (LUST) on the premises (Table 3-2). However, the OHM historically stored in this UST was diesel fuel and fuel oil, not chlorinated VOCs. GEI did not include this LUST in the Phase II CSA because reportedly the chemicals stored in the UST are not related to the COPCs at the Site and the LUST site was closed with a Class A-3 RAO in 1994.

4. Site Geology and Hydrogeology [310 CMR 40.0835(4)(d)]

Information presented in this section is compiled from GEI's Phase I Report, GEI's IRA Status Reports No. 1 through 5, and GEI's IRA and Phase II sub-surface investigative activities. The majority of subsurface investigations were conducted with DEP approval as IRA activities; however, the installation of several monitoring wells, hydraulic conductivity testing, quarterly groundwater monitoring and shallow soil sampling were conducted as Phase II activities as described below.

4.1 Background

MCP response actions at the Site began in October 2003 and have been on-going since that time.

The chronology of subsurface Site investigations includes:

- 2002-2003: Sanborn Head and Associates (SHA)
- 2004: GeoInsight, Inc. (GeoInsight)
- 2006-2008: GEI

Boring logs and well completion reports from previous site investigations are in Appendix F. Table 4-1 is a summary of boring and monitoring wells installed at the Site. Locations of borings and monitoring wells are shown in Fig. 4-1. Details of subsurface investigations performed by GEI from May 2006 through May 2008 are summarized in Tables 4-2 through 4-6. Historic and recent soil and groundwater data for the Site are presented in Section 5.0 of this report.

4.2 Sanborn Head: 2002-2003

In 2002, Mr. Margaglione, a prospective purchaser of the Property, engaged SHA to conduct an environmental due diligence investigation on the property. SHA performed a subsurface exploration program consisting of the advancement of 10 soil borings (SH-1 through SH-5, SH-B1, SH-B2, and SH-MW1 through SH-MW3), the installation of eight monitoring wells (SH-1 through SH-5, and SH-MW1 through SH MW3), and the collection of soil and groundwater samples for laboratory analyses. The locations of the borings and monitoring wells are shown in Fig. 4-1. Boring and monitoring well logs prepared by SHA are in Appendix F. A summary of boring and monitoring well information is in Table 4-1.

Soil samples were submitted to Alpha Analytical Laboratories (now Alpha Woods Hole Labs (AWHL)) of Westborough, Massachusetts for laboratory analysis. Five samples (from SH-1 through SH-4 and SH-B1) were tested for VOCs, extractable petroleum hydrocarbon (EPH) fractions, and volatile petroleum hydrocarbon (VPH) fractions; one sample (from SH-5) was tested for VOCs and EPH fractions; and three of the samples (from SH-MW1 through SH-MW3) were tested for VOCs only.

The borings were terminated in the overburden at depths ranging from 12 to 25 feet, except for SH-MW1, which was advanced into bedrock and was terminated at a depth of 30 feet. The monitoring well installed in SH-MW1 was screened in both the overburden and the bedrock from 10 to 30 feet.

At the time SHA performed the investigation, it observed three existing wells on the Property (MW1 through MW3; Fig. 4-1). SHA and Mr. Margaglione did not determine when or by whom these wells were installed on the Property. Therefore, boring and monitoring well logs for these locations were not found and construction details of the wells are not known.

4.3 GeoInsight: 2004

In August 2004, on behalf of Atlantic National Trust, LLC, GeoInsight performed subsurface investigations at the Site consisting of the installation of two monitoring wells (GEO-1 and GEO-2) on the northern portion of the Property, four monitoring wells (GEO-3 through GEO-6) on the eastern side of Tufts Street, and two soil borings (Soil Boring-1 and Soil Boring-2) on the southern portion of the Property. The locations of the borings and monitoring wells are shown in Fig. 4-1. Boring and monitoring well logs prepared by GeoInsight are in Appendix F. A summary of boring and monitoring well information is in Table 4-1. Soil and groundwater samples were collected and submitted to Spectrum Analytical, Inc. for laboratory analysis of VOCs.

4.4 GEI: 2006-2008

4.4.1 Monitoring Well Installation and Soil Sampling

GEI engaged Geosearch Earth Exploration, Inc. (Geosearch) of Fitchburg, Massachusetts, and Geologic Earth Exploration, Inc. (GeoLogic) of Norfolk, Massachusetts to advance 33 borings and complete them as monitoring wells between May 1, 2006 and January 23, 2008 at the Site. Drilling included:

- Twenty-five shallow borings (MW101 through MW112, MW112A, MW113 through MW115, MW117S, MW118S, MW119S, MW120S, MW121S, MW122, and MW201 through MW203) ranging from 10 to 25 feet deep completed as shallow overburden groundwater monitoring wells. Eighteen of these monitoring wells were

constructed to also serve as subsurface soil vapor monitoring points, as discussed in Section 4.4.3.

- Three intermediate borings (MW117T, MW118T, and MW119T) ranging from 45 to 49.5 feet deep were completed as deep overburden monitoring wells.
- Five bedrock borings (MW116, MW117D, MW118D, MW120D, and MW121D) ranging from 15 to 80 feet deep were completed as bedrock monitoring wells. MW116 was also constructed to serve as a subsurface soil vapor monitoring point, as discussed in Section 4.4.3.
- Monitoring well locations are shown in Fig. 4-1 and a summary of the drilling activities is in Table 4-2. Details of borings and monitoring well construction are in Table 4-1. Boring logs and well completion forms are in Appendix F.

Fifteen of the shallow overburden monitoring wells (MW101-MW114) were installed using a Geoprobe®. The remaining ten shallow overburden monitoring wells (MW115, MW117S, MW118S, MW119S, MW120S, MW121S, MW122, and MW201 through MW203) and three deep overburden monitoring wells (MW117T, MW118T, and MW119T) were drilled using hollow-stem auger and/or drive and wash drilling methods. Three bedrock monitoring wells (MW117D, MW118D, and MW121D) were installed using drive-and-wash and rock coring methods. Four-inch permanent casing was seated in bedrock at MW117D and MW118D prior to rock coring to prevent communication between the shallow, deep and bedrock groundwater. Two bedrock monitoring wells (MW116 and MW120D) were installed using casing and down-hole air hammer drilling methods.

Spilt-spoon samples were generally collected continuously in each boring. GEI screened the samples in the field for VOCs using the jar headspace method and submitted selected samples to Accutest for laboratory analysis of VOCs by U.S. Environmental Protection Agency (EPA) Method 8260.

GEI submitted representative soil samples of the major strata (fill, silt, and till) from MW117D, MW118D, MW121D, and MW122 to PTS Laboratories (PTS) of Santa Fe Springs, California for grain-size and dry bulk density analyses. GEI also submitted up to two rock core samples from each bedrock boring for analysis of total organic carbon (TOC), matrix porosity, and matrix density. Results of soil grain-size and dry bulk density analyses, and bedrock TOC, matrix porosity, and matrix density analyses (Tables 4-7 and 4-8) were used in hydraulic conductivity calculations and plume stability analyses included in Appendices G and H, respectively. Results of hydraulic conductivity testing are discussed in Section 4.10.2 and the plume stability analysis is summarized in Section 10.6.3.

Monitoring wells were installed in each of the 33 borings. Boring logs and monitoring well construction forms are in Appendix F. GEI developed the completed wells by over pumping and extracting a minimum of 10 well volumes from each new well.

GEI conducted hydraulic conductivity tests in 31 wells listed in Table 4-3 between April and December 2007. These tests were intended to evaluate hydraulic conductivity in both overburden and bedrock at the Site. The results are discussed in Section 4.10.2.

On August 8, 2007, GEI observed Geosearch abandon SH-MW1 on the Property by removing the roadbox and the top approximately 3 feet of the well, including the surface seal, and filling the remaining monitoring well and annular space with a pressurized Portland cement and bentonite grout. The monitoring well was abandoned because it was screened across the overburden and bedrock contact. The former location of SH-MW1 is in Fig. 4-1.

4.4.2 Shallow Soil Sampling

Shallow soil samples were collected as part of Phase II activities were collected at selected locations across the Site at representative residential and commercial properties across the Site and in the community gardens at the Capuano Center. The samples were submitted to Accutest for laboratory testing of the site-specific list of selected chlorinated VOCs in Table 4-9 by EPA Method 8260.

4.4.2.1 Residential and Commercial Properties

In February and March 2008, GEI collected 12 soil samples from representative residential and commercial properties at the Site, and five soil samples from the Property. Soil samples were collected from approximately 0.5 to 2 feet deep using a hand auger and garden trowel. Soil samples were screened for the presence of VOCs using a PID and the DEP's jar headspace method, and submitted to Accutest for laboratory analysis for the site-specific list of chlorinated VOCs by EPA Method 8260 (Table 4-9).

A summary of shallow soil sampling activities is in Table 4-4 and sampling locations are shown in Fig. 4-2.

4.4.2.2 Shallow Soil Sampling: Capuano Community Gardens

On March 30, 2007, GEI used a hand auger and garden trowel to collect two shallow soil samples (Fig. 4-2) for chlorinated VOC analysis from the community garden located northeast of the Capuano Center on Franklin Street. The soil samples were collected in native material at a depth of approximately 2.5 feet, which is just below a layer of imported organic soil. The samples were submitted to Accutest for laboratory analysis for the site-specific list of chlorinated VOCs by EPA Method 8260 (Table 4-9), except for soil samples collected at 4 and 13 Morton Street which were analyzed for the full MCP list of VOCs.

4.4.2.3 Shallow Soil Sampling: 95R Franklin Street

GEI collected nine soil samples from beneath the basement slab at 95R Franklin Street on December 5, 11, and 14, 2007 during EPEM installation activities. GEI collected six additional soil samples from outside the house footprint on January 8 and 9, 2008.

Most of the soil samples from beneath the basement slab were submitted to Accutest and analyzed for VOCs, semivolatile organic compounds (SVOCs), polycyclic aromatic hydrocarbons (PAHs), EPH, polychlorinated biphenyls (PCBs), total metals, TOC, reactive cyanide, reactive sulfide, pH, specific conductivity, ignitibility, and percent solids. Three samples from beneath the basement slab, and the samples collected outside the building footprint were analyzed for VOCs and TOC only.

4.4.3 Subsurface Soil Vapor Monitoring Point Installation and Sampling

During monitoring well installation from January 2007 through January 2008, GEI observed Geosearch or GeoLogic install twenty-three groundwater monitoring wells that would also serve as subsurface soil vapor sampling points. Monitoring well construction was modified by increasing the length of the screen above the water table to allow for soil vapor infiltration. To prevent the infiltration of air into the well, the drilling subcontractor sealed the annular space around the well with a thicker layer of hydrated bentonite chips than is typically used in monitoring well construction. GEI also equipped each monitoring well with a subsurface soil vapor sampling port and valve. The top of each monitoring well was sealed with a removable pipe cap and gasket, and the cap was not removed for 24 hours prior to subsurface soil vapor sampling. Monitoring well construction reports are in Appendix F.

GEI conducted quarterly subsurface soil vapor sampling between January 2007 and January 2008, and at selected additional locations in March and October 2007 and January 2008. Dates of subsurface soil vapor sampling events conducted between January 2007 and January 2008 are in Table 4-5. Locations of monitoring wells with subsurface soil vapor sampling points are in Fig. 4-1. Soil vapor sampling checklists were previously submitted to DEP in IRA Status Reports Nos. 1 through 5. Subsurface soil vapor samples were submitted to Accutest for analysis of the site-specific list of chlorinated VOCs by EPA Method TO-15 (Table 4-9).

4.4.4 Groundwater Sampling

Beginning in May 2006, GEI typically conducted monthly water level gauging and quarterly groundwater sampling at existing and newly constructed monitoring wells. Construction details of existing and new wells are in Table 4-1. Details of gauging and monitoring events are summarized in Table 4-6, and monthly groundwater elevations are in Table 4-10. A groundwater contour plan from March 2008 is in Fig. 4-3.

Groundwater samples were collected using low-flow sampling techniques for laboratory analysis of VOCs by EPA Method 8260. In July 2007, groundwater samples were submitted to Accutest for laboratory analysis by EPA Method 8260 for the site-specific list of chlorinated VOCs (Table 4-9).

Selected groundwater samples collected in January 2007 were submitted to Accutest and were tested for natural attenuation parameters, including: surfactants, alkalinity, arsenic, iron III, TOC, nitrate, nitrite, sulfate, sulfide, chloride, methane, ethane, pH, oxidation-reduction potential (ORP), conductance, and dissolved oxygen (DO).

4.4.4.1 DEP Screening at the Capuano Center

DEP installed three temporary well points (MW DEPA – MW DEP C) at the Capuano Center on May 30 and 31, 2007 and collected groundwater samples for analytical screening of chlorinated VOCs on May 31, 2007. The aqueous concentration of VOCs was estimated based on headspace screening techniques. The locations of the well points are shown on Fig. 4-1.

DEP also collected four plant samples from the community gardens for Plant Headspace Screening. DEP collected three leaf samples (yellow leaf, grape leaf, and Leanne's flowers) from the Oliver Street Garden and one leaf sample (mint leaf) from the Franklin Street Garden. The leaf samples were placed in glassware and the headspace concentration in the glassware was measured.

4.4.4.2 Irrigation Well Sampling

On June 25, 2007, GEI collected a water sample from the irrigation system at the Cobble Hill Apartments located at 84 Washington Street and submitted it to Accutest for laboratory analysis of VOCs by EPA Method 8260. Water for the irrigation system is supplied by a bedrock irrigation well (Fig. 4-1) located on the southern portion of the 84 Washington Street property. According to information obtained from Mr. Bob Keene of Corcoran Jennison Management, LLC, the management company for the Cobble Hill Apartments, the well is approximately 300 feet deep. According to Mr. Keene, bedrock was encountered at 76 ft bgs during drilling.

4.5 Geophysical Survey

In April and June 2007, GEI engaged Hager Geoscience (Hager) of Woburn, Massachusetts to perform a Site-wide geophysical survey to locate the bedrock surface. Hager conducted the survey by performing approximately 17 transects using ground penetrating radar (GPR) and three transects using seismic methods. Seismic methods were used to calibrate GPR depth conversions. Hager performed GPR transects using two different antenna frequencies,

40 and 100 megahertz (MHz). Transect locations are shown on the figure included in the GPR Survey Report in Appendix I.

4.6 Regional Geology

The Site is located approximately 15 to 35 feet above sea level (Fig. 1-1). It is located in the Charles River and Mystic River drainage basin. Regional groundwater flow is expected to be either north to northeast toward the Mystic River or south to southeast toward the Charles River as shown in Fig. 4-4. The Site area is characterized by extensive urban development which has significantly altered the local topography.

4.6.1 Fill History

According to an 1857 survey of the United States coast, tidal inlets of the Charles River were located southeast of the Site prior to the mid-19th century. Publications by Seasholes (2003) and Krieger et al. (1999) show that these tidal inlets, which include Miller's Creek, Mill Pond and Prison Point Pond, were filled circa 1860. Land along the South side of the Mystic River and the North side of the Charles River was also filled. The fill is of unknown composition and was placed over pre-existing salt marsh, intertidal land, and shallow offshore areas. Areas of historic filling are shown in Fig. 4-4.

4.6.2 Surficial Geology

According to GEI's subsurface investigations, Skeehan (2001), Barosh and Woodhouse (1991 and 2006), and Kaye (1978), the regional surficial geology is characterized by the river valleys of the Charles River and Mystic River drainage basin that are filled with unconsolidated deposits. In general, the unconsolidated deposits include surficial estuarine silt, peat, and alluvium which are underlain by marine clay and outwash, which in turn are underlain by basal (lodgemont) till.

Surficial geology in the localized Site area typically includes urban fill overlying brown, glacial till composed of silt with fine sand and sub-angular gravel. Stratified Drift in the Site area consists of undifferentiated glacio-fluvial sand and gravel, alluvial and estuarine soils, and minor clay and till, that is in places overlain by organic soils. Localized areas of organic soil and fill are found near the filled tidal inlets. Soft blue marine clay overlies glacial till in some areas. Rocky Terrain consisting of thin glacial till directly overlying shallow bedrock with numerous, closely spaced outcrops is located to the Southeast of the Site in Charlestown. Details regarding on-site overburden stratigraphy are presented in Section 4.8.

4.6.3 Bedrock Geology

According to Skeehan (2001) and Barosh and Woodhouse (1991, 2006), the Site area is located within the Boston Basin of the Avalon Terrane. The Boston Basin is a fault-bounded, topographic basin of relatively unmetamorphosed sedimentary and volcanic bedrock.

According to Kaye (1978, 1980, and 1982), the Site is underlain by the Precambrian Cambridge Argillite. The Cambridge Argillite (a.k.a Cambridge Slate) bedrock consists of gray argillite (primarily mud and clay) with interbedded sandstone and/or quartzite. The bedrock is laminated, to massively bedded, with bedding plane partings that are generally poorly developed with locally imperfect slaty cleavage. The argillite is locally deeply weathered and altered to kaolinite clay.

Regional depth to bedrock is estimated to range from between 3.5 and 55 feet at the Site to approximately 100 feet adjacent to the Charles and Mystic Rivers based on boring data compiled in the Journals of the Boston Society of Civil Engineers (1961 and 1984). Generalized regional cross-sections and a cross-section location plan are in Figs. 4-4, 4-5, and 4-6.

Based on GEI drilling and geophysical investigations, depth to bedrock at the Site varies, but is approximately 30 feet near the Property in the northwestern portion of the Site and generally increases to approximately 50 feet in the southeastern portion of the Site near Washington Street. A bedrock ridge extends from Tufts Street to the southern end of the Capuano Center as shown on the geophysical bedrock contour map included in the geophysical survey report in Appendix I. Based on the Site geophysical survey, there are no other significant bedrock highs. Details regarding the on-site bedrock stratigraphy are presented in Section 4.8.

4.7 Topography

The surficial topography of the Site slopes downward from the Property to the east and southeast. The surface elevation of the Site ranges from approximately 35 feet above North American Vertical Datum (NAVD; 1988) near the northwest edge of the Site to approximately 15 feet above NAVD (Fig. 1-1) near the southeast edge of the Site. Regionally, the area generally slopes gently east-southeast toward the Mystic River and south-southeast toward the Charles River (Figs. 1-1 and 4-4).

4.8 Geology Description

Based on GEI's investigation, individual strata thickness may vary across the borings. The units described below are based on individual boring locations and may not be present everywhere across the Site. GEI encountered the following strata at the Site:

- Fill: Fine to coarse sand with some silt and gravel was present to shallow depths at the Site, approximately 1 to 18 feet thick.
- Silt: Underlying the surface fill deposits is a unit of silt, ranging from 0 to 35 feet thick. It is gray to olive in color with medium density and plasticity. Silt deposits are thickest in the vicinity of a historic pond located on the current Capuano Center property.
- Till: Underlying the silt layer is a unit of glacial till, ranging from 3 to 15 feet thick. The till is a dense unit consisting mostly of fine to coarse sand with varying amounts of silt and gravel. The till layer tends to be thin to absent in locations where bedrock is shallow (e.g., MW116 and MW119).
- Bedrock: The top of bedrock was encountered in the borings at 3.5 feet deep in MW116, approximately 45 feet deep in MW117D and MW119T, 50 feet deep in MW118D, and approximately 23 feet deep in MW120D and MW121D. A fine-grained, gray, low-grade metamorphic rock was observed in the bedrock borings and identified as argillite of the Cambridge Argillite Formation on the U.S. Geological Survey Bedrock Map of Massachusetts (1983). Quartzite, also considered a characteristic member of the Cambridge Argillite formation, was observed from 55 to 75 feet deep in MW118D. Typically, the upper 15 to 20 feet of bedrock was highly fractured and highly weathered in the borings where it was encountered.

A cross-section location plan is in Fig. 4-7 and site cross-sections are in Figs. 4-8 through 4-12.

4.9 Groundwater System

Based on subsurface investigations, the groundwater system at the Site is composed of three units:

- Shallow overburden in the fill and silt;
- Deep overburden; and
- Bedrock.

Regional groundwater in the vicinity of the Site is expected to flow either north-northeast toward the Mystic River, or south-southeast toward the Charles River. Based on the Site-

specific information presented below and the regional geology cross-sections (Figs. 4-5 and 4-6), groundwater is expected to flow downward into bedrock in the vicinity of the Site and immediately downgradient of the Site as a result of recharge, and then travel laterally until it ultimately discharges into the Mystic or Charles Rivers. This conceptual model of regional groundwater flow is supported by water levels in the study area that are typically higher in overburden than in bedrock.

4.9.1 Groundwater Level Measurements

GEI conducted monthly groundwater level measurements in the monitoring wells at the Site (Table 4-10 and Fig. 4-3). The depth to water in the shallow overburden ranges from approximately 8.5 to 13 ft bgs. The direction of groundwater flow in the system across the central portion of the Site is generally toward the southeast – from the Property toward Franklin Street. However, the flow direction in the shallow overburden is locally influenced by underground utilities and potentially by the presence of historic building foundations.

4.9.2 Groundwater Gradients

Groundwater level readings for monitoring wells in different strata (Table 4-10) indicate that in general the shallow overburden exhibits the highest water levels, followed by the deep overburden, and then the bedrock, which has the lowest water levels. Based on these groundwater level measurements, overall the vertical flow gradients are downward in the system, i.e., groundwater flows primarily horizontally in all geological units but with a slight downward component from the shallow overburden into the deep overburden, and subsequently downward into the bedrock. The downward component of flow stems from recharge to the overburden.

4.10 Hydraulic Conductivity Testing

4.10.1 In-Situ Permeability Testing

The hydraulic conductivity of the shallow overburden, deep overburden, and bedrock strata (discussed in Section 4.8) was evaluated by conducting single well hydraulic tests at groundwater monitoring wells selected to represent each strata. The results from these tests provide an evaluation of the hydraulic conductivity of the strata in which the well screens are installed and were used to aid in the evaluation of groundwater flow velocity and the ability of contaminants to migrate by the process of advection within the bulk groundwater flow at the site. The stratum in which each well is screened is noted in Table 4-1. Permeability testing included both rising and falling head tests.

In December 2007, GEI performed in situ rising and falling head permeability tests using slug test methods.

Rising head slug tests were performed by inserting one or more plastic bailers into a well and then rapidly removing the slug of water from the well to create drawdown of the water level in the well. Rising head permeability testing was conducted on monitoring wells that had either partially saturated screens (a portion of the screen was above the water table) or saturated screens (the screen was entirely below the water table). Hydraulic conductivity values for rising head slug tests were calculated using the Bouwer and Rice method as implemented in the "Super Slug" software package.

Falling head slug tests were performed by inserting a solid plastic cylinder (slug) into a well, temporarily elevating the water level. The slug remained in the well for the duration of the falling head test. Falling head permeability testing was conducted only in monitoring wells that had fully saturated screens. Hydraulic conductivity values for falling head slug tests were calculated using the Hvorslev method as implemented in the "Super Slug" software package.

Rising-head slug tests were performed in the following groundwater monitoring wells:

- Wells screened in fill and/or silt: GEO-1, GEO-2, GEO-3, GEO-5, GEO-6, SH-MW3, MW101, MW102, MW109, MW111, MW112A, MW117S, MW118S, MW119S, MW121S, MW201, MW202;
- Wells screened in deep overburden: MW117T, MW118T, MW119T; and
- Wells screened in bedrock: MW116 and MW120D.

GEI also conducted in-situ falling head permeability tests in groundwater monitoring wells MW117T, MW118T, MW119T, MW116, and MW120D, and MW122.

During both the rising head and falling head slug tests, recovery of the water level was monitored using a water level indicator and recorded using a miniTroll® data transducer.

Hydraulic conductivity values are summarized in Table 4-11. The data used to calculate the hydraulic conductivity at each well is provided as Appendix G, along with the Bouwer and Rice and/or Hvorslev graphs and equations. A discussion of the results is presented in Section 4.10.2.

4.10.2 ***Results of Hydraulic Conductivity Testing***

Ranges of calculated hydraulic conductivities for each geologic unit are summarized below. These ranges are typical of geologic deposits exhibiting a moderate to high degree of heterogeneity.

- Shallow overburden: 9.82×10^{-5} to 1.57×10^{-3} centimeters per second (cm/s).
- Deep overburden: 6.54×10^{-4} to 3.28×10^{-2} cm/s.

- Bedrock: 8.0 X 10^{-7} to 2.20 X 10^{-2} cm/s.

4.11 Underground Utility Evaluation

GEI evaluated underground utilities as potential contaminant migration pathways and exposure points. The primary utilities within the Site that are believed to be potential migration pathways include the storm drains and sanitary sewers. The interiors of selected, readily-accessible storm drains and sanitary sewers were evaluated as described below. Potential migration of contaminants in bedding material along the exterior of the underground utilities was evaluated based on contaminant concentrations in soil vapor and groundwater in monitoring wells near the utilities; however, no indications of significant contaminant migration along the exterior of underground utilities were observed. In general, sanitary sewer lines lie at or below the seasonal fluctuations of the groundwater table. The main exceptions are the 8-inch vitreous clay sanitary sewer line on the east side of Franklin Street (Fig. 2-1), which is above the water table. The storm water drainage catch basins on Washington Street beneath the MBCR railroad bridge (CB19, CB20, CB33, and CB34) are below the water table.

In March and April 2008, GEI conducted an evaluation to determine whether groundwater impacted with chlorinated VOCs is infiltrating storm drains and/or sanitary sewers within the Site. GEI measured the depth to invert and depth to water. Total VOC headspace concentrations within the structure were screened with a PID, and water samples were collected for laboratory analysis of the site-specific list of chlorinated VOCs by EPA Method 8260 (Table 4-9) at selected manholes and catch basins. Manhole and catch basin locations evaluated are shown in Fig. 2-1.

4.11.1 Physical Characteristics of Utilities

Prior to collecting a water sample from a manhole or catch basin, GEI photographed the structure, recorded observations of utility construction and condition, and measured water levels and depth to bottom. Water level and utility measurements are summarized in Tables 4-12 and 4-13. Laboratory data reports are in Appendix J.

The majority of storm water catch basins are constructed of brick masonry, except for the newly constructed catch basins near the Capuano Center. The sanitary sewers and inverts are primarily constructed of brick masonry, but some are constructed of vitreous clay, for example, the piping in sanitary manhole SMH47 at the corner of Glen and Fountain Streets. From a review of historical maps, most of the brick piping connecting these structures was originally constructed in the 1880s.

4.11.2 Air VOC Measurements

GEI screened ambient air above the water surface at each sewer manhole and catch basin for VOCs using a PID. Results of the PID readings are included in Tables 4-12 and 4-13. The majority of VOC readings were less than 1 part per million (ppm), except for storm water catch basins CB19 and CB33, on Washington Street beneath the MBCR railroad bridge, where the adjusted PCE headspace concentrations were 3 and 11 ppm, respectively. These measurements are consistent with laboratory analytical results for water samples collected from the structures, in which the highest concentrations of PCE were detected in samples collected from catch basins CB19 and CB33.

5. Subsurface Investigation Testing Results

5.1 Soil Testing Results

5.1.1 Soil Borings – Chemical Testing

The results of laboratory analysis of soil borings are presented in Table 5-1, and results of soil and bedrock physical properties analysis are presented in Table 4-7 and 4-8, respectively. Laboratory data for soil analyses were submitted previously to DEP in IRA Status Reports No. 1 through 5. The results of the laboratory analysis of subsurface soil samples are shown in Fig. 5-1.

The laboratory detected VOCs in soil samples from 14 of the 33 borings, and chlorinated VOCs in soil samples from 12 of the 33 borings. The laboratory identified the following chlorinated VOCs in soil samples from the Site:

- 1,1-Dichloroethane (MW104 and MW107).
- cis-1,2-Dichloroethylene (MW104).
- Methylene chloride (MW118D).
- PCE (MW102, MW103, MW104, MW109, MW111, MW112A, MW118D, MW122, MW201, and MW203).
- TCE (MW101, MW104, and MW112A).
- TCA (MW104).

Detected PCE concentrations ranged from 0.125 milligrams per kilogram (mg/kg) in MW203 to 4.25 mg/kg in MW104. Detected TCE concentrations ranged from 0.138 mg/kg in MW112A to 0.593 mg/kg in MW104. These soil concentrations are well below the thresholds that would indicate the presence of DNAPL (Kueper, 2008b).

Additional VOCs detected in at least one boring include benzene (MW118D), naphthalene (MW115 and MW117D), 1,2,3-trimethylbenzene (MW115), and total xylenes (MW104 and MW115). These are not COPCs.

5.1.2 Shallow Soil Samples: Site-Wide

The results of the chemical testing of shallow soil samples are included in Table 5-2 and shown in Fig. 5-2. Laboratory data sheets are in Appendix J.

The laboratory reported PCE at a concentration of 0.537 mg/kg in the sample collected from the residence at 4 Morton Street. PCE concentrations at the Property ranged from 0.326 to 43.2 mg/kg. One soil sample at the Property (Soil 1) also contained 0.123 mg/kg of TCE and 0.716 mg/kg of TCA.

5.1.3 Shallow Soil Samples: Capuano Community Gardens

No chlorinated VOCs were detected above laboratory RLs in either of the two shallow soil samples collected on March 30, 2007 from the community garden located northeast of the Capuano Center on Franklin Street. The results are shown in Fig. 5-2. Laboratory data reports associated with the sampling were submitted in IRA Status Report No. 4, dated November 9, 2007.

5.1.4 Shallow Soil Samples: 95R Franklin Street

The results of the laboratory analysis of shallow soil samples collected at 95R Franklin Street are in Table 5-3. Laboratory data sheets are in Appendix J, and sketches showing sampling locations are in Appendix K. Shallow soil sample results are included in Table 5-2 and shown on Fig. 5-2.

PCE was detected in soil samples collected from beneath the basement slab at concentrations ranging from less than laboratory RLs to 58.9 mg/kg. TCE was detected in soil samples collected from beneath the basement slab at concentrations ranging from less than laboratory RLs to 6.17 mg/kg. cis-1,2-Dichloroethylene was detected at concentrations ranging from less than laboratory RLs to 0.772 mg/kg. Chlorinated VOCs were not detected at concentrations above laboratory RLs in soil samples collected from outside the building footprint.

AMEC conducted a site-specific risk assessment to evaluate potential health risks posed by the contaminants associated with the property at 95R Franklin Street (PCE, TCE and cis-1,2-dichloroethylene). Based on the site-specific risk assessment, the VOCs do not pose a significant health risk for any current or future use, including residential use. The site-specific risk assessment is in Appendix K.

Lead, arsenic and several PAHs were detected at concentrations above the applicable reportable concentration (RCS1) in the MCP. The lead, arsenic, and PAHs are associated with the fill beneath the basement slab and are not COPCs.

It is GEI's opinion that the lead detected in the soil samples is related to paint chips observed in the soil and are exempt from notification in accordance with the MCP, 310 CMR 40.0317(8). In addition, it is GEI's opinion that the arsenic and PAHs detected in

the soil samples are related to ash, coal ash, or wood ash observed in the soil and are also exempt from notification in accordance with the MCP, 310 CMR 40.0317(9).

Although the soil is exempt from notification under the MCP, it was managed in a manner consistent with the MCP. Excavated soil for off-site disposal was chemically characterized and disposed of at an appropriate facility.

5.2 Subsurface Soil Vapor Testing Results

The results of the laboratory analysis of soil vapor samples collected from soil vapor monitoring wells are presented in Table 5-4 and shown in Fig. 5-3. Laboratory data reports were previously submitted to DEP in IRA Status Reports No. 1 through 5. Laboratory data reports received since the last Status Report submittal (March 31 through May 9, 2008) are in Appendix J.

In five rounds of subsurface soil vapor sampling, the laboratory generally detected chlorinated VOCs above laboratory RLs in the soil vapor monitoring wells. PCE, TCE, and TCA were generally detected in soil vapor samples from each of the monitoring wells in at least one round of sampling. Concentrations of:

- PCE ranged from 1.6 $\mu g/m^3$ in MW108 to 1,360,000 $\mu g/m^3$ in MW111;
- TCE ranged from 1.2 $\mu g/m^3$ in MW119S to 6,400 $\mu g/m^3$ in MW116; and
- TCA ranged from 1.3 $\mu g/m^3$ in MW107 to 12,800 $\mu g/m^3$ in MW111.

Additional chlorinated VOCs detected in at least one subsurface soil vapor sample include carbon tetrachloride, chloroethane, 1,1-dichloroethane, 1,1-dichloroethylene, 1,2-dichloroethane, trans-1,2-dichloroethylene, 1,1,2-trichloroethane, and vinyl chloride.

5.3 Groundwater Testing Results

The results of the laboratory analysis of groundwater samples are presented in Table 5-5 and chlorinated VOC results are shown in Figs. 5-4 through 5-6. Laboratory data sheets are in GEI's IRA Status Reports No. 1 through 5.

In each round of the groundwater sampling, the laboratory detected VOCs above the laboratory RLs in the monitoring wells at the Site except for MW110, MW113, MW114, MW115, MW117S, and MW118S. The laboratory identified at least one of the 40 VOCs listed in Table 5-5. Chlorinated VOCs, particularly 1,1-dichloroethylene, PCE, TCE, and TCA were detected in samples collected from more than half of the monitoring wells. Concentrations of:

- 1,1-Dichloroethylene ranged from 1.0 µg/l in MW202 to 11,500 µg/l in MW1;

- PCE ranged from 1.0 µg/l in MW106 to 74,900 µg/l in MW1;
- TCE ranged from 1.2 µg/l in MW118D to 175,000 µg/l in MW1; and
- TCA ranged from 1.2 µg/l in MW121D to 255,000 µg/l in MW1.

In January 2007, GEI submitted groundwater samples from eight selected monitoring wells for chemical testing of surfactants, alkalinity, arsenic, iron III, total organic carbon (TOC), nitrate, nitrite, sulfate, sulfide, chloride, methane, ethane, pH, ORP, conductance, and DO. The laboratory detected the following compounds above laboratory RLs:

- Arsenic in MW110;
- Chloride in MW103, MW106, MW107 MW108, MW110, GEO-2, and SH-MW3;
- Iron in MW106, MW107, MW110, and SH-MW3;
- Nitrogen compounds in MW103, MW106, MW107, MW110, GEO-2, GEO-6, and SH-MW3;
- Sulfate at MW103, MW106, MW107, MW108, MW110, and SH-MW3;
- Sulfide at MW107; and
- TOC at MW103, MW106, MW108, and MW110.

The lack of surfactants in the water samples comfirms that the high concentrations of chlorinated VOCs in groundwater are attributable to dissolution of DNAPL, rather than an artifact of any surfactant-enhanced solubility effects.

5.3.1 DEP Screening at the Capuano Center

On May 30 and 31, 2007, DEP collected three groundwater samples from temporary well points installed at the Capuano Center for analytical screening. The DEP Analytical Screening Data Report is in Appendix J.

The screening method detected the following ranges of compounds above the estimated RLs:

- 1,1-Dichloroethylene ranged from 17 µg/l in DEP-2 @ 34 ft to 50 µg/l in DEP-1 @ 25 ft;
- cis-1,2-Dichloroethylene at 6.2 µg/l in DEP-3 @ 24 ft;
- PCE ranged from 37 µg/l in DEP-3 @ 24 ft to 44 µg/l in DEP-2 @ 34 ft;
- TCE ranged from 19 µg/l in DEP-2 @ 34 ft to 21 µg/l in DEP-3 @ 24 ft; and
- TCA at 1.5 µg/l in DEP-3 @ 24 ft.

On May 30, 2007, DEP collected four leaf samples for Plant Headspace Screening. Chlorinated VOCs were not detected in the headspace above the estimated RL. The DEP Analytical Screening Data Report is in Appendix J.

5.3.2 Irrigation Well Sampling Results

On June 25, 2007, GEI collected a water sample for laboratory analysis from the irrigation system, supplied by a bedrock well, located at 84 Washington Street. Results of the testing are presented in Table 5-5. The laboratory detected low levels of acetone and chloroform in the water sample. No other VOCs were detected in the sample above laboratory RLs.

According to Mr. Bob Keene of Corcoran Jennison Management, LLC, a water sample collected from the well on June 23, 1993 met EPA drinking water standards, despite having a slightly elevated salt content.

5.4 Underground Utilities – Water Testing Results

GEI collected water samples from selected storm drain and sewer manholes with disposable Teflon bailers (Fig. 2-1). The water samples were submitted to Accutest for analysis of the site-specific list of chlorinated VOCs by EPA Method 8260 (Table 4-9). Sampling locations and laboratory analytical results of water samples are summarized in Table 5-6.

With the exception of a limited portion of the Site discussed below, utilities in general do not appear to be impacted by or serve as a preferential flow pathway for dissolved chlorinated VOCs in groundwater. Samples collected from storm water catch basins and sewer manholes on Tufts, Glen and Knowlton Streets, the northeast portion of Franklin Street, and at the intersection of Washington and Joy Streets contained no detectable concentrations of chlorinated VOCs, as indicated in Table 5-6.

The laboratory detected chlorinated VOCs in water from storm water catch basins with elevated PID readings (CB19 and CB33), and in water from two sanitary sewer manholes (SM102 and SMH44). PCE was measured at 5170 µg/l, 2090 µg/l, and 406 µg/l in CB10, CB33, and CB34, respectively and at 279 µg/l and 87.4 µg/l in SM102 and SMH144, respectively.

6. The Property Indoor Air Evaluation and Mitigation

Information presented in this section primarily is a summary of GEI's previous submittals to DEP, including the Phase I Initial Site Investigation and IRA Status Reports No. 1 through No. 5. Sampling surveys, checklists, photograph logs, and laboratory data sheets associated with sub-slab vapor and indoor air sampling at the Property were included in previously submitted IRA Status Reports. The majority of the activities conducted at the Property were conducted as IRA activities as described below.

6.1 SHA Investigation (2002)

SHA collected a sample of indoor air from the office portion of the Property building in 2002 and submitted the sample for laboratory analysis of VOCs. PCE (6290 $\mu g/m^3$), TCE (234 $\mu g/m^3$) and related chlorinated VOCs were detected at elevated concentrations in the air sample. Based on the air testing results, SHA concluded there was a potential for an Imminent Hazard to a 40 hours per week commercial worker when evaluated over a period of five years.

6.2 Mitigation Measures Installed by GEI

GEI installed an SSDS at the Property to:

- Eliminate or mitigate the soil vapor exposure pathway, and
- Achieve a condition of no Imminent Hazard for a hypothetical commercial full-time employed worker (40 hours per week).

The SSDS began operating on April 30, 2007. The SSDS includes 22 sub-slab extraction points inside the Property building that are operated by a 15 horsepower (HP) blower with pressure gauges, controls, and a particulate filter (Figs. 6-1, 6-2a, and 6-2b). The extracted soil vapor is filtered through two 2,000 lb tanks of granular activated carbon operated in series.

GEI also installed an SVE system on the Property to:

- Reduce the mass of contaminants in soil vapor, and
- Control the migration of soil vapor.

The SVE began operating on August 22, 2007. The SVE system includes seven soil vapor extraction points installed through the pavement in the north and south parking lots that are connected to the same blower and off-gas treatment as the SSDS (Fig. 6-2a and 6-2b).

System installation and operation details are provided in IRA Status Reports No. 3 through 5, previously submitted to DEP. The SSDS and SVE system continues to operate. Monitoring data collected for the SSDS show vacuum influence in the sub-slab monitoring points inside the building, which indicates that the system is capturing soil vapor beneath the slab, preventing its migration to indoor air. Monitoring data collected for the SVE system show vacuum influence at the soil vapor monitoring points in the north parking lot and extending onto the 60 Tufts Street property. Vacuum influence in the south parking lot extends approximately 30 feet south of the building face.

6.3 Indoor and Outdoor Air Sampling at the Property

GEI collected air samples inside and outside the building to evaluate indoor air quality at the Property, and to verify the effectiveness of the SSDS and SVE system. Indoor and outdoor air samples were collected over a 4-hour period using Summa canisters on May 1 and 14, June 28, August 28, October 1, and December 7, 2007. Data collected during the sampling events, including environmental conditions, were recorded on Ambient Air Sampling Checklists, previously submitted to DEP. The samples were submitted to Accutest for laboratory analysis of the site-specific list of chlorinated VOCs by EPA Method TO-15 (Table 4-9).

6.4 Results of Indoor and Outdoor Air Testing Results

Laboratory results for indoor and outdoor air testing at the Property are summarized in Tables 6-1 and 6-2, and Fig. 6-3.

The results of the first two air sampling rounds, collected on May 1 and 14, 2007, likely were affected by the presence of liquid PCE, which was discovered in several pipes hanging in the rafters of the building and subsequently removed on June 21, 2007. Similarly, the fourth sampling round, collected on August 28, 2007, was affected by a nearby roll-off storing excess soil generated during installation of the SVE system. The roll-offs containing the excess soils were subsequently removed from the Property.

Unlike the results of sampling conducted in May 2007, the round of indoor air samples collected on June 28, 2007 was representative of conditions during operation of the SSDS, but prior to start-up of the SVE system. The average VOC concentration measured in indoor air samples collected inside the Property building during the June 2007 sampling is below the Imminent Hazard level of 58.8 $\mu g/m^3$ for a Commercial Worker.

Unlike the results of sampling conducted in August 2007, the rounds of indoor air samples collected on October 4 and December 7, 2007 are considered representative of conditions during operation of the combined SSDS and SVE system. The concentration at each sampling location measured during both of these sampling dates is below the Imminent Hazard level for a Commercial Worker.

7. Residential and Commercial Properties Indoor Air Evaluations and Mitigation

Off-property information presented in this section primarily is a summary of GEI's previous submittals to DEP including the Phase I Initial Site Investigation and IRA Status Reports No. 1 through No. 5. Sampling surveys, checklists, photograph logs, and laboratory data sheets associated with sub-slab vapor and indoor air sampling were included in previously submitted IRA Status Reports. The majority of the activities conducted at the residential and commercial properties were conducted as IRA activities as described below. A list of residential and commercial properties evaluated during IRA activities is included in Table 7-1.

7.1 DEP Indoor Air Evaluation along Tufts Street (2005)

On December 21, 2004, DEP issued a Notice of Response Action – Interim Deadline (NRA) to 50 Tufts Street, Inc. to evaluate indoor air at six residences across Tufts Street and evaluate utility lines within Tufts Street to determine whether an SRM condition existed. 50 Tufts Street, Inc. did not undertake the required response actions.

DEP conducted an indoor air screening program at residences located at 9, 11/13, 19, 25, and 27 Tufts Street. DEP contacted residents and obtained access agreements. On February 9, 2005, DEP conducted indoor air screening for chlorinated VOCs in the basement and first floor of each residence. The only analyte detected was 1.8 $\mu g/m^3$ of PCE in an air sample from the basement of 19 Tufts Street.

In February and March 2005, DEP coordinated the sampling of indoor air for laboratory testing at the residences located at 9, 11/13, 17, 19, 23, 25, and 27 Tufts Street. Shaw collected samples over a 4-hour period from the basement and the first floor of each residence. Accutest analyzed the samples for selected chlorinated VOCs by EPA Method TO-15 (Table 4.9) (Refer to Section 12.2 for a description of the analyte list). PCE was detected in air samples from each residence except 27 Tufts Street. PCE concentrations ranged from 0.95 $\mu g/m^3$ to 8.8 $\mu g/m^3$, with the highest concentration detected in a sample collected at 17 Tufts Street. The concentrations reported were below DEP published concentrations for background levels of PCE in residential indoor air at the time.

7.2 GEI Indoor Air Evaluation along Tufts Street (2006)

Quarterly indoor air testing was initiated by GEI in residences along the southern portion of Tufts Street (9, 11-13, 17, 19, 23, 25, and 27) in March 2006 . Indoor air samples were

collected over a 4-hour period using Summa canisters and submitted to Accutest for laboratory analysis of the site-specific list of chlorinated VOCs by EPA Method TO-15 (Table 4-9). Indoor air samples were typically collected from the basement and first floor. The results of the indoor air testing are in Tables 7-2a through 7-63a.

In the second quarter sampling round, PCE concentrations in the basement samples of 23 and 27 Tufts Street and the first floor sample of 23 Tufts Street were significantly higher than previously measured in the first quarter sampling event (March 2006). Based on these concentrations and an initial Imminent Hazard Evaluation, UniFirst reported to DEP on August 1, 2006 the potential for an Imminent Hazard at 23 and 27 Tufts Street. DEP assigned RTN 3-26114 to this notification.

GEI collected additional air samples in the basements and first floor of 23 and 27 Tufts Street on August 3, 2006 to confirm the original test results and further evaluate the potential for an Imminent Hazard. PCE concentrations in samples collected in the August 2006 samples were significantly lower than those collected in June 2006. Based on the additional data and an updated Imminent Hazard Evaluation, UniFirst retracted the Imminent Hazard Notification, as documented in our letter dated September 21, 2006. In a letter dated October 11, 2006, DEP disputed the retraction.

The two final rounds of indoor air testing were collected in September/October and December 2006. At the conclusion of the year-long quarterly sampling program, chlorinated VOCs were detected in each of the residences sampled along the southern portion of Tufts Street. The presence of PCE above laboratory RLs in the living space of an occupied residential dwelling constituted a CEP. UniFirst therefore offered to install an SSDS at each of the residences. An SSDS was installed in the residence at 23 Tufts Street; the remaining property owners refused installation of an SSDS.

7.3 GEI Additional Indoor Air Evaluation (Winter 2007)

Following several community meetings, and at the request of property owners, GEI conducted indoor air testing in several residences and commercial properties on Alston Street, Dell Street, Franklin Street, Knowlton Street and Tufts Street in January and February 2007. Indoor air samples were collected over a 4-hour period using Summa canisters and submitted to Accutest for laboratory analysis of the site-specific list of chlorinated VOCs by EPA Method TO-15 (Table 4-9). Samples were typically collected from the basement and first floor. The properties sampled and the dates of indoor air sampling are in Table 7-1. The results of the indoor air testing are in Tables 7-2a through 7-63a.

Based on the indoor air testing results, along with groundwater and subsurface soil vapor test results from sampling points located along and upgradient of Dell Street, it is GEI's opinion that the indoor air quality in residences along Dell Street are not affected by the Site.

7.4 GEI Vapor Intrusion Evaluation

Based on Site-wide groundwater, soil, and indoor air sampling results, GEI identified a several-block area near the Property for evaluation of soil vapor intrusion as a potential exposure pathway. GEI identified 72 residential and commercial properties (excluding the Property building, the Capuano Center, and Dell Street) to be evaluated. These properties are listed in Table 7-1 and are shown on Fig. 7-1. GEI evaluated the potential for vapor intrusion at 62 of these properties. GEI could not obtain contact information for, or was unable to reach, four property owners and four property owners refused testing.

7.4.1 Evaluation Process

GEI established the following process presented in IRA Plan Modification No. 1 (RTN 3-26114), dated April 12, 2007, to evaluate residential and commercial buildings and address the vapor intrusion exposure pathway.

- Establish criteria for recommending an EPEM or additional evaluation.
- Contact property owner.
- Inspect the building and collect sub-slab soil vapor samples.
- Based on the sub-slab soil vapor sample results, recommend an EPEM or additional evaluation, if necessary.
- Conduct additional evaluation by collecting indoor air samples, if necessary.
- Conduct an EPEM, if warranted.

7.4.2 Criteria for Mitigation in Residences

Based on the concentrations of chlorinated VOCs detected in the sub-slab soil vapor, GEI established preliminary assessment criteria in residences for: (1) mitigation to eliminate the potential exposure pathway by installing an EPEM; (2) indoor air testing to confirm the absence or presence of an exposure pathway and whether or not mitigation is warranted; or (3) no additional action. The assessment criteria were:

- Installing an EPEM: Total chlorinated VOCs greater than 561 $\mu g/m^3$
- Indoor air testing: Total chlorinated VOCs between 10 and 561 $\mu g/m^3$
- No additional action: Total chlorinated VOCs less than 10 $\mu g/m^3$

AMEC derived the sub-slab soil vapor concentration action level to conduct mitigation (561 $\mu g/m^3$) based on the methodology embedded in the Johnson-Ettinger model to derive an acceptable indoor air concentration of PCE to achieve a level of NSR based on the URF that DEP had previously published. The sub-slab soil vapor action level requiring no additional

action (10 μg/m^3) was provided by DEP. These conservative screening values were used solely for purposes of the preliminary vapor intrusion evaluation. Derivation of the criteria was presented in IRA Plan Modification No. 1 (April 2007).

7.4.3 Criteria for Mitigation in Commercial Buildings

Based on the concentrations of chlorinated VOCs detected in the sub-slab soil vapor, GEI established preliminary assessment criteria at commercial properties for: (1) mitigation to eliminate the potential exposure pathway by installing an EPEM; (2) indoor air testing to confirm the presence of an exposure pathway and whether or not mitigation is warranted; or (3) no additional action. The assessment criteria were:

- Installing an EPEM: Total chlorinated VOCs greater than 2,992 μg/m^3
- Indoor air testing: Total chlorinated VOCs between 32 and 2,992 μg/m^3
- No additional action: Total chlorinated VOCs less than 32 μg/m^3

AMEC derived the commercial sub-slab soil vapor concentration action level to install an EPEM (2,992 μg/m^3) based on the methodology embedded in the Johnson-Ettinger model to derive an acceptable indoor air concentration of PCE to achieve a level of NSR, based on the URF that DEP had previously published. The commercial sub-slab soil vapor action level requiring no additional action (32 μg/m^3) was calculated based on an NSR level and a very conservative indoor air attenuation factor selected by DEP. These conservative screening values were used solely for purposes of the preliminary vapor intrusion evaluation. Derivation of the criteria was presented in IRA Plan Modification No. 1 (April 2007).

7.4.4 Criteria to Conduct Indoor Air Testing in Residences

IRA Plan Modification No. 1 (April 2007) stated that indoor air sampling and testing would be conducted at residences where the concentration of PCE in the sub-slab soil vapor is greater than 10 μg/m^3 and less than 561 μg/m^3. However, as a further conservative measure, indoor air testing was conducted at many residences where the sub-slab vapor sampling results were less than 10 μg/m^3 if the residence was proximate to elevated concentrations of PCE in groundwater.

7.5 GEI Sub-Slab Soil Vapor Evaluation

7.5.1 Sub-Slab Soil Vapor Sampling

GEI inspected and collected sub-slab soil vapor samples at 56 residential and commercial properties between February 28 and September 30, 2007. Fig. 7-1 shows buildings where GEI conducted sub-slab soil vapor sampling. Sub-slab soil vapor sampling was not

conducted at the residences along the southern portion of Tufts Street (9, 11-13, 17, 19, 23, 25, and 27) since indoor air testing previously identified CEPs in those residences.

GEI typically installed up to two sub-slab soil vapor monitoring points in each building GEI sampled. The procedure for installing sub-slab vapor monitoring points was presented in IRA Status Report No. 3 (May 2007). Soil vapor samples were collected over a 1-hour period using Summa canisters and submitted to Accutest for laboratory analysis of the site-specific list of chlorinated VOCs by EPA Method TO-15 (Table 4-9).

7.5.2 Sub-Slab Soil Vapor Testing Results

Laboratory results of sub-slab soil vapor testing are presented in Tables 7-2b through 7-63b. Based on the sub-slab soil vapor testing results, one of the following actions was recommended for each residence or commercial building:

- Conduct mitigation as an EPEM; or
- Conduct additional indoor air testing.

GEI recommended conducting indoor air testing at 40 of the buildings and conducting an EPEM at three buildings. The buildings where sub-slab vapor sampling was conducted, and the recommended actions based on the results, are in Table 7-1.

7.6 GEI Indoor Air Evaluation (2008)

7.6.1 Indoor Air Sampling

Between April 8, 2007 and May 9, 2008, GEI collected indoor air samples at 46 residences and commercial buildings. Fig. 7-1 shows buildings where GEI conducted indoor air sampling. The procedure for collecting indoor air samples was presented in IRA Status Report No. 3 (May 2007). Indoor air samples were collected over a 4-hour period using Summa canisters and submitted to Accutest for laboratory analysis of the site-specific list of chlorinated VOCs by EPA Method TO-15 (Table 4-9). Samples were typically collected from the basement and first floor.

7.6.2 Indoor Air Testing Results

Laboratory results of indoor air testing conducted between April 8, 2007 and May 9, 2008 are presented in Tables 7-2a through 7-63a.

Based on the indoor air testing results, one of the following actions was recommended for each residence or commercial building:

- Conduct mitigation as an EPEM;

- Conduct additional indoor air testing; or
- Prepare a Class B Response Action Outcome-Partial (RAO-P) Statement.

The buildings where indoor air testing was conducted, the dates of sampling, and the recommended actions based on the testing results, are in Table 7-1.

7.7 EPEM Vapor Mitigation

To mitigate the vapor intrusion exposure pathway in residences and commercial buildings, GEI is installing EPEMs. As of May 9, 2008, GEI has recommended conducting EPEMs at 29 buildings – three based on sub-slab soil vapor results and 26 based on indoor air results. These recommendations are noted in Table 7-1. Prior to installing an EPEM, GEI installed air purifiers in residences as a temporary mitigation measure.

To date EPEMs have taken the form of either an SSDS or a vapor barrier and venting system. Initially SSDSs were installed; however, based on data collected after installation of several systems, together with an evaluation of soil and building conditions on these and other properties, GEI concluded that an SSDS may not be the appropriate EPEM at many locations. Therefore, GEI designed an alternative vapor barrier and venting system, tailored to the individual characteristics of each building.

An EPEM in the form of an SSDS is appropriate for buildings with a competent concrete slab floor, concrete walls, and good sub-slab air flow. An alternative EPEM, consisting of a vapor barrier and venting system, is appropriate for buildings that have a compromised slab or dirt basement floor, fieldstone or brick foundation, and/or poor sub-slab air flow.

Table 7-1 lists the buildings where an air purifier has been installed and those where EPEMs have been installed. These locations are shown on Fig. 7-1.

7.7.1 Temporary Measure - Air Purifiers

As of May 9, 2008, 21 indoor air purifiers had been installed at residences at the Site. A description of the air purifiers and specification sheets were included in IRA Plan Modification No. 1 (April 2007). The buildings where an air purifier is currently installed are listed in Table 7-1 and shown on Fig. 7-1.

GEI removes the air purifier following the installation of an EPEM. An air purifier was re-installed at 95 Franklin Street when indoor air testing indicated that concentrations of PCE were measured above laboratory RLs. GEI typically conducts routine maintenance on the air purifiers on a quarterly basis.

7.7.2 Sub-Slab Depressurization Systems

As of May 9, 2008, GEI had installed SSDSs in the residences and commercial buildings listed in Table 7-1. The systems installed are similar to those commonly used to address radon, as shown in Figs. 7-2 and 7-3.

GEI retained Norfolk Services Inc. (Norfolk) of Bridgewater, Massachusetts, and Storch Radon Services, Inc. (Storch) of Taunton, Massachusetts, to install the SSDSs. The SSDSs were installed between May 7 and August 24, 2007.

Based on post-mitigation indoor air testing, the SSDSs have been effectively mitigating the vapor intrusion pathway at 23 Tufts Street and 18 Morton Street. Post-mitigation indoor air sampling results are in Tables 7-12c, 7-13c, 7-42c, 7-45c, and 7-52c. GEI did not conduct indoor air testing at 103 Washington Street since it is an automotive repair business. Instead GEI monitored the pressure of the SSDS to demonstrate its effectiveness.

Based on post-mitigation sampling, building conditions and characteristics at 95 Franklin Street, 95R Franklin Street and 31-33 Knowlton Street are not optimal for operation of an SSDS. Post-mitigation indoor air sampling results are in Tables 7-12c, 7-13c, 7-42c, 7-45c, and 7-52c. A vapor barrier and venting system EPEM has been installed at 95R Franklin Street and one is scheduled to be installed at 95 Franklin Street. Modifications to optimize the SSDS are planned at 31-33 Knowlton Street to allow drainage of condensate accumulating in the SSDS suction pits.

7.7.3 Vapor Barrier and Venting System

Based on the results of tests and inspections conducted during its evaluation, GEI concluded that an SSDS may not be the appropriate EPEM for many buildings. The geologic conditions beneath the building slab, the absence of a competent basement slab and/or the presence of fieldstone foundations may impede effective operation of an SSDS; therefore, GEI proposed an alternative EPEM based on property-specific conditions. The alternative EPEM is a vapor barrier and venting system tailored to the specific conditions encountered in each building, and may include sealing the existing concrete floor, installing a vapor barrier system on the fieldstone (and/or brick) foundation walls, and/or installing a venting system beneath the vapor barriers.

Two versions of the vapor barrier and venting system were initially proposed and have been implemented:

- **Option 2: Seal concrete floor, vapor barrier wall system, and venting**. Option 2 was proposed for buildings with a competent concrete slab floor, a fieldstone or brick foundation, and poor sub-slab air flow.

- **Option 3: New concrete floor, vapor barrier wall system, and venting.** Option 3 was proposed for buildings with a poor quality concrete or dirt floor, a fieldstone or brick foundation, and poor sub-slab air flow.

IRA Plan Modification No. 10, submitted to DEP on December 17, 2007, summarized the EPEM options and presented a generic Option 2 methodology. IRA Plan Modification No. 11, submitted April 9, 2008, presented the Option 3 Methodology for 12 Morton Street. Schematics of Option 2 and Option 3 are presented in Figs. 7-4 and 7-5 and protocols for each Option are in Appendix L.

On May 30, 2007, an SSDS was installed in the basement and crawl space at 95R Franklin Street. Due to dense, fine-grained soil beneath the floor slab, the SSDS did not function optimally. An Option 2 EPEM was installed in December 2007. Indoor air testing was conducted following the installation of the EPEM on August 23, 2007, November 15, 2007, December 13, 2007 and December 28, 2007. The laboratory results are in Table 7-13c.

Based on the condition of the existing concrete slab, an Option 3 EPEM was installed at 12 Morton Street. Installation began on January 14, 2008 and was completed on March 4, 2008. Indoor air testing was conducted following the installation of the EPEM on March 5, 2008 and March 21, 2008. The laboratory results are in Table 7-42c.

Based on the results of the work completed at 95R Franklin Street and 12 Morton Street, together with data gathered from inspections of other buildings for which EPEMs have been recommended, GEI determined that vapor barrier wall systems may not be essential components in each instance in which an Option 2 or Option 3 EPEM is implemented.

7.8 Additional Indoor Air Testing

In several instances, additional indoor air testing was conducted in residences and buildings even if the sub-slab soil vapor testing results did not indicate, based on the criteria outlined in Section 7.5, that mitigation or further testing was warranted. Particularly where a building was located in proximity to elevated concentrations of PCE in shallow groundwater, GEI undertook indoor air testing to confirm the results of sub-slab soil vapor testing. DEP acknowledged this approach in its written approval for IRA Plan Modification No. 1, dated June 19, 2007:

- Three rounds of indoor air testing (November/December, February/March, and during the summer) in residences and commercial buildings where no indoor air impact was found, if the buildings are believed to be located within the boundaries of the shallow groundwater plume associated with the Site. A monitoring plan beyond the first year is to be submitted to DEP for review and comment.

GEI has continued to conduct this additional indoor air testing. The dates of additional sampling are in Table 7-1 and the laboratory testing results are in Tables 7-12c, 7-13c, 7-42c, 7-45c, and 7-52c.

7.9 Class B Response Action Outcome-Partial Statement

GEI will prepare Class B RAO-P Statements based on lines of evidence establishing an incomplete vapor intrusion pathway in residences and commercial buildings at the edges of the Site.

7.9.1 Residences and Commercial Buildings at the Site Boundry

Based on the following lines of evidence, we will conclude that the vapor intrusion pathway is incomplete for residences and commercial properties at the Site boundary:

- Extrapolation of chlorinated VOC concentrations detected in groundwater samples collected from nearby monitoring wells indicates the concentration of chlorinated VOCs in shallow groundwater beneath the property are less than the MCP Method 1 GW-2 Standard (50 µg/l for PCE).
- Application of DEP-derived attenuation factors to concentrations of chlorinated VOCs detected in soil vapor samples collected from nearby monitoring wells indicates the indoor air concentrations are below the DEP indoor air risk-based concentrations.
- Chlorinated VOCs have not been measured in indoor air samples collected from nearby buildings at concentrations above the laboratory RL.

7.9.2 Residences and Commercial Buildings with Sub-slab and/or Indoor Air Data

Based on the following lines of evidence, GEI will conclude that the vapor intrusion pathway is incomplete at those residences and commercial buildings where additional indoor air testing described in Section 7.8 is not required:

- The concentration of chlorinated VOCs in shallow groundwater (less than 15 ft bgs) located beneath the building is less than the current applicable GW-2 standard. This conclusion may be based on extrapolation of measured groundwater concentrations in monitoring wells in the vicinity of the residence or commercial building.
- The concentration of PCE in soil vapor beneath the building's slab (if collected) is less than 10 µg/m^3. For those buildings for which soil vapor has not been collected from beneath the slab, GEI still may conclude that the vapor intrusion pathway is

incomplete based on the other lines of evidence described herein, including soil vapor concentrations measured in nearby monitoring wells.

- Chlorinated VOCs have not been measured in indoor air above the laboratory RL, which for PCE is 0.2 ppbv or 1.4 μg/m^3 based on three rounds of indoor air testing.

The residences and commercial buildings for which sufficient data has been collected to support a Class B RAO-P are listed in Table 7-1.

7.10 Outdoor Air Sampling and Testing

7.10.1 Outdoor Air Sampling

Between March 23, 2006 and January 23, 2007, GEI collected outdoor air samples contemporaneously with rounds of indoor air sampling undertaken at the Site. Outdoor air sampling locations are shown in Fig. 7-6.

Outdoor air samples were collected over a 4-hour period using Summa canisters and submitted to Accutest for laboratory analysis of the site-specific list of chlorinated VOCs by EPA Method TO-15 (Table 4-9). The procedure for collecting outdoor air samples was presented in IRA Status Reports No. 1 through No. 3.

7.10.2 Outdoor Air Testing Results

Results of outdoor air testing are presented in Table 7-64 and shown in Fig. 7-5.

The laboratory detected chlorinated VOCs, including PCE, TCA, and chloromethane in some of the outdoor air samples. The laboratory detected PCE in seven of 22 samples at concentrations ranging from 1.6 μg/m^3 (Tufts-O-2B collected on October 2, 2006) to 8.1 μg/m^3 (Tufts-O-1B collected on June 28, 2006). The laboratory also detected TCA in one sample (Tufts-O-2B collected on June 29, 2006). Concentrations of chloromethane, detected in eight samples, ranged from 1.1 μg/m^3 (Tufts-O-1B collected on March 24, 2006) to 1.8 μg/m^3 (Tufts-O-2A collected on June 29, 2006). Methylene chloride was detected in eight samples, but was attributed to laboratory contamination.

7.11 60 Tufts Street

The building at 60 Tufts Street consists of 17 condominium units and a parking garage deck. It is adjacent to the Property.

Based on multiple rounds of groundwater measurements, the prevailing direction of groundwater flow at the Property is to the east-southeast across Tufts Street towards Knowlton Street and Franklin Street. Based on the results of soil, soil vapor and indoor air

samples collected at 50 and 60 Tufts Street, to a limited extent soil vapor has migrated radially from the Property, across the prevailing direction of groundwater flow.

Chlorinated VOCs have been measured in indoor air at, and in soil vapor below 60 Tufts Street. Indoor air samples were collected over a 4-hour period using Summa canisters and submitted to Accutest for laboratory analysis for the site-specific list of chlorinated VOCs by EPA Method TO-15 (Table 4-9). Sub-slab vapor and indoor air testing results at various locations at 60 Tufts Street are in Tables 7-57a and 7-57b. Chlorinated VOCs were not detected above laboratory RLs in groundwater samples collected from wells on the 60 Tufts Street property (MW201 and MW202).

7.11.1 **SVE System**

Since chlorinated VOCs were not detected in groundwater at concentrations that would constitute a potential source of VOCs to the indoor air, GEI's approach to mitigating the indoor air at 60 Tufts Street was to control potential migration of chlorinated VOCs in soil vapor to the Property. This design criterion was included as one goal during the remedial investigation and installation of the SVE system on the Property.

The SVE began operating on August 22, 2007 and continues to operate. The SVE system is described in Section 6.2. Monitoring data collected for the SVE system show vacuum influence at the soil vapor monitoring points in the north parking lot and extending onto the 60 Tufts Street property.

7.11.2 **Pilot Extraction Test**

GEI collected indoor air samples at 60 Tufts Street in November 2007, after the SVE system had been installed and operated, and measured chlorinated VOCs above laboratory RLs. In January 2008, GEI conducted a sub-slab SVE pilot test in the basement of the building at 60 Tufts Street. The objective was to reduce the concentration of VOCs in the soil vapor beneath the sub-slab, and to collect data to evaluate the effectiveness of the extraction. As part of the pilot test GEI also conducted a soil communication test to evaluate the vacuum radius of influence at various locations across the basement. Chlorinated VOCs continued to be measured above laboratory RLs in sub-slab soil vapor and in indoor air at 60 Tufts Street following the pilot test. However, the pilot test did indicate that an SSDS located at 60 Tufts Street should be an effective method of reducing VOCs in sub-slab soil vapor and mitigating the potential migration into indoor air. An SSDS will be installed subject to approval by the property owners.

8. Capuano Center Property Indoor Air Evaluation and Mitigation

Information presented in this section primarily is a summary of GEI's previous submittals to DEP including the Phase I Initial Site Investigation and IRA Status Reports No. 1 through No. 5. The sampling surveys, checklists, photograph logs, and laboratory data sheets associated with sub-slab vapor and indoor air sampling were included in previously submitted IRA Status Reports. The majority of the activities conducted at the Capuano Center property were conducted as IRA activities as described below.

8.1 Initial Indoor Air Testing

During school vacation, on December 27 and 28, 2006, GEI conducted air sampling at several indoor and two outdoor locations at the Capuano Center. Indoor air samples were collected over a 4-hour period using 6-liter Summa canisters and submitted to Accutest for laboratory analysis of the site-specific list of chlorinated VOCs by EPA Method TO-15 (Table 4-9). Although there were no detectable levels of PCE in the majority of classrooms and common areas, PCE was detected in indoor air samples collected in three classrooms (Classrooms 138, 142 and 146). Sample locations for December 27 and 28, 2006 are shown in Figs. 8-1 and 8-2, respectively. Results of outdoor and indoor air sampling are summarized in Tables 8-1 and 8-2, respectively.

8.2 Indoor Air Quality Evaluation

In response to the detection of PCE in three classrooms (Classrooms 138, 142 and 146), GEI and Environmental Health and Engineering of Newton, Massachusetts (EH&E) conducted an indoor air quality evaluation. The evaluation included:

- A review of the engineering and construction details of the building.
- Inspection and testing of its heating, ventilation, and air conditioning (HVAC) system.
- Field screening for chemicals using a PID.
- Laboratory testing of indoor air samples collected throughout the building.

EH&E performed a comprehensive evaluation of the HVAC system at the Capuano Center. EH&E then made adjustments to the HVAC system to optimize its operation and return it to the original design specifications, which created a positive pressure in the building. The adjustments made to the HVAC system decreased PCE concentrations measured in indoor

air. Additional indoor and outdoor air samples were collected throughout the evaluation period. Indoor air samples were collected over a 4-hour period using 6-liter Summa canisters and submitted to Accutest for laboratory analysis of the site-specific list of chlorinated VOCs by EPA Method TO-15 (Table 4-9). The locations of indoor and outdoor air samples collected through the evaluation period (December 2006 through January 31, 2007) are shown in Figs. 8-1 through 8-6.

EH&E also reduced the potential migration of sub-slab vapor to indoor air by sealing penetrations in the slab that potentially allowed soil vapor to migrate from the subsurface into the unit ventilators (UVs) in selected classrooms.

8.3 Sub-Slab Depressurization System

The presence of chlorinated VOCs above the laboratory RL in the indoor air at the Capuano Center represents a CEP; therefore, GEI designed and oversaw the installation of an SSDS to mitigate migration of chlorinated VOC vapors from beneath the floor slab into indoor air.

In January 2007, the SSDS was installed along the southern wing of the Capuano Center under six classrooms (Classrooms 122, 126, 134, 138, 142, and 146). The SSDS was activated on February 1, 2007. Piping configurations for the SSDS are shown in Figs. 8-7 and 8-8, and a system schematic is in Fig. 8-9.

To increase the effectiveness of the SSDS, GEI arranged for sealing a potential vapor intrusion pathway between the foundation wall and slab along the exterior wall of six classrooms (122, 126, 134, 138, 142, and 146) in August 2007.

8.4 Mitigation Monitoring

Monitoring the mitigation measures implemented at the Capuano Center consisted primarily of weekly mechanical inspections and monthly monitoring and air sampling. Details of weekly inspections and monthly monitoring are presented in previously submitted IRA Status Reports No. 1 through 5. A summary of monthly indoor and outdoor air sampling activities is below.

8.4.1 Monthly Indoor and Outdoor Air Sampling

GEI collected monthly indoor and outdoor air samples at the Capuano Center from February 2007 to May 2008 as part of SSDS operation monitoring. Indoor air samples were collected over a 4-hour period using 6-liter Summa canisters and submitted to Accutest for laboratory analysis of the site-specific list of chlorinated VOCs by EPA Method TO-15 (Table 4-9). Sampling was not conducted in June 2007, and was delayed in August 2007 due to curricular activities and access constraints at the Capuano Center.

The locations of indoor and outdoor air samples were generally the same during each monthly sampling event and are shown in Fig. 8-10. Indoor air samples were collected in Classrooms 126, 138, 141, 142, and 146. Outdoor air samples were typically collected on the roof downwind of the SSDS exhaust pipe.

8.4.2 Monthly Indoor and Outdoor Air Sampling Analysis Results

Results of outdoor and indoor air sampling are summarized in Tables 8-1 and 8-2, respectively.

In general, VOCs were not detected in the indoor air samples collected from the classrooms after the installation of the SSDS in February 2007. However, in July 2007, low levels of VOCs were detected in two of the classrooms (Room 138 and Room 146). These detections were attributed to a potential vapor intrusion pathway between the foundation wall and slab along the exterior wall of six classrooms (122, 126, 134, 138, 142, and 146). After sealing the foundation wall-slab joint in August 2007, VOCs have not been detected in indoor air samples collected from the classrooms.

9. Environmental Fate and Transport [310 CMR 40.0835(4)(e)]

9.1 Physical and Chemical Properties of Site Contaminants

The physical and chemical properties of contaminants affect their fate and transport in the subsurface. The nature and extent of contaminant transport are determined by the interactions among contaminant transport properties and the subsurface environment. Taken together, the properties describe the tendencies of a particular compound to move through and/or to accumulate in various media. Among the chemical and physical properties of the contaminants that affect fate and transport in groundwater and soil are molecular weight, vapor pressure, water solubility, Henry's Law constant (gas-liquid partitioning), specific gravity, organic carbon partition coefficient (K_{oc}), and other partition coefficients.
A summary of the chemical and physical properties of site-specific chlorinated VOCs is presented in Table 9-1.

9.2 Principal Chlorinated VOCs

Chlorinated VOCs are the identified COPCs at the Site. PCE, TCE, and TCA are the principal chlorinated VOCs detected at elevated concentrations in soils, groundwater, soil vapor, and/or indoor air at the Site. Relatively low concentrations of other chlorinated VOCs were detected occasionally.

As with most chlorinated hydrocarbons, liquid PCE, TCE, and TCA are heavier than water and are classified as DNAPLs. If PCE, TCE, and TCA in the form of DNAPLs are spilled, they will migrate downward through surficial materials (e.g., porous concrete, soil, etc.) and through both unsaturated and saturated media until they either reach a capillary barrier, or they have become distributed completely as residual DNAPL. Residual DNAPL refers to disconnected blobs and ganglia of organic liquid that are formed at the trailing end of a DNAPL body. Any DNAPL that accumulates above a capillary barrier is referred to as connected phase DNAPL. Because the local directions of DNAPL migration are influenced by even subtle variations in soil texture and permeability, finding the individual zones of residual and connected phase DNAPL is not a practicable site characterization objective. In practice, site data are evaluated to determine overall volume of the subsurface within which isolated zones of residual and connected phase DNAPL exist.

The description of each of the three primary chemicals (PCE, TCE, and TCA) present at the Site, which are described below, was obtained from the Agency for Toxic Substances and Disease Registry (ATSDR) on-line database, as updated on September 11, 2007.

9.2.1 Tetrachloroethylene (PCE)

PCE is a manufactured chemical used for a variety of purposes including dry cleaning, metal degreasing, and as a chemical intermediate in the production of a variety of consumer and industrial products. PCE is a colorless nonflammable liquid at room temperature. It evaporates easily into the air and has a sharp, sweet odor. Most people can smell PCE when it is present in the air at a level of 1 part PCE per million parts of air (1 ppm) or more, although some can smell it at even lower levels.

9.2.2 Trichloroethylene (TCE)

TCE is a manufactured, nonflammable, colorless liquid with a somewhat sweet odor and a sweet, burning taste. It is used mainly as a solvent to remove grease from metal parts, but it is also an ingredient in a variety of products including adhesives, paint removers, typewriter correction fluids, and spot removers. The odor threshold for TCE is approximately 100 ppm.

9.2.3 1,1,1-Trichloroethane (TCA)

TCA is a manufactured, colorless liquid historically used as a degreaser and chemical intermediate in the production of a variety of consumer and industrial products including spot removers, glues, and aerosol sprays. Manufacturing of TCA for domestic use in the United States was halted as of January 1, 2002 because of its adverse effect on the ozone layer.

9.3 Groundwater Transport and Retardation Mechanisms

Subsurface plume migration is controlled by the physical and chemical properties of the contaminant and the nature of the subsurface media through which the contaminant is migrating. Several processes are known to affect the movement of contaminants in the subsurface, including:

- Groundwater flow (advection);
- Diffusion;
- Dispersion;
- Sorption;
- Volatilization;
- Biodegradation; and
- Hydrolytic transformation (abiotic transformations).

In January 2007, selected groundwater samples were tested for natural attenuation parameters to evaluate biologic and/or abiotic degradation processes that may affect the fate and transport of VOCs at the Site. Natural attenuation parameter testing included: alkalinity,

arsenic, iron III, TOC, nitrate, nitrite, sulfate, sulfide, chloride, methane, ethane, pH, ORP, conductance, DO, and VOC concentrations. Natural attenuation parameter testing results are presented in Table 5-5.

9.3.1 Groundwater Flow

Groundwater flow is the principal process responsible for the transport of dissolved contaminants since they flow (advect) with the groundwater. Variations of permeability, porosity, and hydraulic gradient govern the groundwater velocity through pores of soil or fractures of bedrock and hence the velocity of contaminant migration.

At the Site, groundwater flow in the shallow overburden is from the Property to the east towards Knowlton Street. Deeper groundwater movement occurs through the deep overburden and through fractures in the bedrock, and also flows towards the east.

9.3.2 Diffusion

Molecular diffusion is the slow movement of particles from an area of high concentration to an area of low concentration. Below the water table, diffusion allows contaminants to enter low permeability media such as clay lenses and the bedrock matrix. Above the water table, air phase diffusion allows contaminants to migrate in directions not necessarily coincident with the direction of groundwater flow. Both aqueous phase and air phase diffusion are occurring at the Site.

9.3.3 Dispersion

Dispersion refers to pore scale and macroscopic scale groundwater velocity variations that cause the leading edge of the contaminant plume to migrate faster than the rate of advection. Dispersion also has vertical transverse and horizontal transverse components, which result in spreading of the contaminant in directions orthogonal to that of groundwater flow. Dispersion is a dilution mechanism that causes source level contaminant concentrations to decrease in the direction of groundwater flow. Dispersion alone can result in the attainment of a steady-state groundwater plume and is occurring in both overburden and bedrock at the Site.

9.3.4 Sorption

Sorption is the attachment of contaminants to organic carbon present on the surfaces of soil particles. Increased organic content of the soil or rock tends to increase the sorption of organic contaminants, particularly those with higher molecular weight. Sorption results in the contaminant migrating at a slower rate than the groundwater. For chemicals such as PCE, TCE, and TCA, it is not uncommon for the rate of contaminant transport to be between two and ten times slower than the groundwater velocity. Sorption is an active process at the

Site, resulting in an attenuated rate of contaminant transport compared to the rate of groundwater flow. Kueper (2008a,b) quantifies the degree of sorption of PCE, TCE, and TCA at the Site.

9.3.5 ***Volatilization***

Volatilization is the partitioning of contaminants between groundwater and soil vapor (liquid and gas phases). Contaminants with higher Henry's Law constants and lower molecular weight and water solubility are generally more volatile. Volatilization from groundwater at the Site is significant over those portions of the shallow overburden with high contaminant concentrations in groundwater, as evidenced by the concentrations of VOCs (particularly PCE) detected in soil vapor.

9.3.6 ***Degradation of Chlorinated VOCs***

Increased chlorination increases the stability of chlorinated hydrocarbons to resist oxidation (also known as dechlorination). Highly chlorinated hydrocarbons are therefore less bio-oxidizable than less chlorinated hydrocarbons.

9.3.6.1 Biodegradation

In the subsurface, degradation of PCE and TCE is catalyzed by soil microorganisms that may occur aerobically (with oxygen) and anaerobically (without oxygen). Under anaerobic conditions, PCE and TCE can be dechlorinated sequentially from PCE to TCE, 1,2-dichloroethane, vinyl chloride, and then finally to ethane through mechanisms of reductive dehalogenation. In aerobic environments, less chlorinated TCE, 1,2-dichloroethane, and vinyl chloride can be oxidized to CO_2 if conditions are favorable. Larger amounts of degradation result in shorter steady-state VOC plumes in groundwater.

Biodegradation occurs naturally in subsurface environments due to the ubiquitous presence of indigenous soil microorganisms that are capable of consuming certain contaminants as a source of organic carbon and/or energy. The potential for organic contaminants to biodegrade varies significantly because the soil microorganisms have to be specifically acclimated to the contaminants. Chlorinated VOCs are relatively recalcitrant, but can be biodegraded if the environmental conditions are favorable. For instance, dechlorination of PCE and TCE may occur under anaerobic environments where other organic sources are available and biological oxidation of 1,2-dichloroethane and vinyl chloride may occur under aerobic environments where sufficient DO is available.

Daughter products and metabolites of PCE and TCE degradation, including trans-1,2-dichloroethylene, cis-1,2-dichloroethylene, 1,1-dichloroethylene, and vinyl chloride were detected in groundwater collected at the Site. The presence of these daughter

products/metabolites indicate that dechlorination by natural attenuation may be occurring. However, the relatively low concentrations of the daughter products/metabolites compared to PCE and TCE indicates that dechlorination is not a significant process in the immediate vicinity of the Property.

With the exception of well MW104, the wells sampled by GEI in January 2007 had DO concentrations greater than 1.0 mg/L, indicating that significant amounts of anaerobic reductive dechlorination of chlorinated hydrocarbons are not likely to be occurring in these areas of the Site. Nitrate (> 1.0 mg/L), sulfate (> 20 mg/L), and iron II (< 1.0 mg/L) concentrations also indicate that significant amounts of anaerobic degradation are not likely to be occurring within this portion of the Site; however, aerobic degradation processes may be occurring.

Well MW104, located on the southern edge of the Site, had a DO concentration of 0.68 mg/L, an iron II concentration of 1.53 mg/L, and ORP of -65.7 millivolts (mV), indicating that conditions in this area may be conducive to anaerobic reductive dechlorination.

9.3.6.2 Abiotic Transformation

In addition to biodegradation, abiotic transformation of chlorinated hydrocarbons can degrade chlorinated VOC compounds. Abiotic transformation is any process in which a chemical in the environment is altered by non-biological mechanisms such as hydrolysis or dehydrohalogenation. Hydrolysis is likely affecting TCA at the Site.

9.3.7 Surfactants

Based on the former use of the Property building as an industrial chemical and laundry supply warehouse, groundwater from selected monitoring wells in the Site vicinity were tested for the potential presence of surfactants. Surfactants are substances that, when dissolved in water, lower the surface tension of the water and increase the solubility of organic compounds. Surfactants (e.g., detergents) may affect the solubility, mobility and degradation of chlorinated VOCs.

Nonionic and ionic surfactants have been used to aid in the solubilization and subsequent removal of DNAPL from contaminated systems. Since ionic surfactants, such as linear alkyl benzene sulfonates, are found in industrial detergents, and may have been used on the Site, groundwater from selected monitoring wells was tested for the potential presence of surfactants. Surfactants, measured as linear alkyl benzene sulfonates, were detected only in a groundwater sample from MW107. Based on groundwater contours and the absence of significant Site-related chlorinated VOCs in groundwater samples from this well, the data

indicates that mobilization of chlorinated solvents due to the presence of surfactants is not likely to be occurring in shallow and deep overburden.

9.4 Dense Non-aqueous Phase Liquid

PCE, TCE, and TCA are liquids that are immiscible with water and therefore may exist as a separate liquid phase in the subsurface. PCE, TCE, and TCA are denser than water and are therefore classified as DNAPLs. Upon release to the subsurface, DNAPL will come to rest as both disconnected blobs and ganglia of organic liquid referred to as residual DNAPL, and in connected phase distributions perched above capillary barriers. The specific migration pathways of DNAPL are influenced by subtle and local variations in soil structure and permeability. DNAPLs will migrate both laterally and vertically downwards in the subsurface in directions that are not necessarily coincident with groundwater flow. Within the overall volume of the subsurface containing DNAPL there will be particular lenses and laminations that contain DNAPL, and others that are void of DNAPL. Locating the particular lenses and laminations that contain DNAPL is not a practicable site characterization objective. As discussed by Kueper (2008b), practicable site characterization objectives include identifying whether DNAPLs exist at a particular site, and delineating the overall volume of the subsurface within which the DNAPLs reside.

The various blobs and ganglia of residual DNAPL (and any connected phase DNAPL that may be present) dissolve slowly into flowing groundwater, giving rise to aqueous phase plumes. Because the aqueous solubility of most DNAPLs is relatively low and groundwater velocities are typically low, it can be many decades before the DNAPL is depleted by these natural processes. Because the vapor pressure of many DNAPL compounds (such as PCE, TCE, and TCA) is relatively high, the lifespan of DNAPL in the unsaturated zone can be much less than the lifespan of DNAPL below the water table.

Based on converging lines of evidence, it is concluded that PCE, TCE, and TCA DNAPLs are present in overburden down to the top of bedrock (and possibly in bedrock) at the Site (Kueper (2008b)). The DNAPL is not present continuously throughout this volume of porous media, but is rather situated in many discrete lenses and laminations of geologic material. DNAPL has not been visually observed in the monitoring wells or in the groundwater or soil samples collected at the Site. Consequently, the majority of DNAPL exists as residual DNAPL, which is immobile as a result of capillary trapping forces. Given the relatively high density and low viscosity of PCE, TCE, and TCA along with the moderate hydraulic conductivity of the overburden deposits, it is concluded that any continuous distributions of DNAPL are also no longer migrating and have been stabilized by capillary trapping forces (Kueper (2008)). The operation of the SSDS and SVE system at the Property is expected to accelerate the process of removing DNAPL from the unsaturated zone.

9.5 Vapor Intrusion

9.5.1 Vapor Intrusion Transport Mechanism

Vapor intrusion is the migration of volatile chemicals from the subsurface into overlying buildings. A vapor intrusion source is a chemical of sufficient volatility and toxicity in the subsurface, with sufficient mass and/or concentrations to pose a possible inhalation risk within current or future occupied structures. This definition includes the presence of a volatile chemical or chemicals adsorbed to, or in the pore space/fractures of unsaturated soil, rock, or in the uppermost portions of the saturated zone. Such vapor sources can exist in the form of residual or connected phase DNAPL, contaminated soil in the vadose zone, and shallow dissolved phase contamination in groundwater. Any of these sources can give rise to vapor plumes that could potentially diffuse and/or advect into overlying buildings and structures.

The rate of movement of vapors into a building depends on soil type, soil moisture content, chemical properties, building design and condition, and the pressure differential across the building floor and walls. In the absence of an air pressure differential across the building floor and walls, diffusion will be the primary vapor migration mechanism. Diffusion is the mechanism by which soil vapor moves from areas of high concentration to areas of low concentration in response to a concentration gradient. Chemicals can potentially volatilize from impacted soil and/or groundwater beneath a building and diffuse toward regions of lower chemical concentration (e.g., the atmosphere, conduits, basements).

Advection is the transport mechanism by which soil vapor moves due to differences in air pressure. These pressure differences can be generated by barometric pressure changes, wind load, thermal currents, building stack effects, or depressurization from building exhaust fans. Advective transport is likely to be most significant in the region very close to a basement or a foundation wall with soil vapor velocities decreasing rapidly with increasing distance away from the structure. Once soil vapors enter the "building zone of influence," they are generally transported into the building through foundation cracks by advection due to the indoor-outdoor building pressure differential.

Upon entry into a structure, soil vapor mixes with the existing air through the natural or mechanical ventilation of the building.

9.5.2 Potential for COPCs to Impact Indoor Air Quality

Vapor intrusion is an exposure pathway at the Site. Chlorinated VOCs, including PCE, TCE, and TCA, have been measured in the indoor air in the building on the Property. In addition, chlorinated VOCs, particularly PCE, have been measured in residences, commercial

buildings, and the Capuano Center downgradient and crossgradient of the source area located at the Property.

9.6 Utilities as Migration Pathways

The potential preferential pathways associated with underground utilities include migration of contaminant vapors, DNAPL, and/or contaminated groundwater into or along the underground utility conduits and structures. The primary utilities within the Site that are believed to be potential migration pathways include the storm drains and sanitary sewers. GEI evaluated underground utilities as potential contaminant migration pathways and exposure points as discussed in Sections 4.0 and 5.0 of this report. This evaluation will continue as requested by DEP in their letter dated June 25, 2008.

10. Contaminant Nature and Extent [310 CMR 40.0835(4)(e)(f)]

Information presented in this section references GEI's findings from IRA, Phase I and Phase II investigations, and the following reports prepared by Kueper (2008a,b):

- "Assessment of DNAPL Presence and Distribution, 50 Tufts Street Site, Somerville, Massachusetts, RTN 3-23246," dated June 21, 2008.
- "Assessment of Source Stability, Plume Stability, and Plume Response Time, 50 Tufts Street Site, Somerville, Massachusetts, RTN 3-23246," dated June 21, 2008.

These reports are presented in Appendices M and H, respectively.

10.1 MCP Definitions

Under the MCP (310 CMR 40.0006), a "Site" is defined as an area where OHM has been deposited, stored, disposed of or placed, or otherwise come to be located. A "release" is defined as any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment. The nature and extent of releases reported at the Site were evaluated based on these definitions.

A source of OHM which *is resulting or is likely to result in an increase in concentrations* of OHM in an environmental medium either by direct discharge or by intermedia transfer (310 CMR 40.1003[5]) must be eliminated, controlled or mitigated. By contrast, if a source is **not** resulting in or is **not** likely to result in an increase in concentrations of OHM in an environmental medium either by direct discharge or by intermedia transfer, then the source control criteria do not apply. If the dissolved phase groundwater plume has reached a steady state and any DNAPLs are not migrating, as is the case here, then there is no source that is resulting in or is likely to result in an increase in concentrations of OHM in an environmental medium.

10.2 Nature of Contamination

The following contaminants have been detected in the soil, soil vapor, and/or groundwater at the Site:

- Chlorinated VOCs: chloroethane, carbon tetrachloride, 1,1-dichloroethane, 1,1-dichloroethylene, 1,2-dichloroethane, trans-1,2-dichloroethylene, cis-1,2-dichloroethylene, TCA, 1,1,2-trichloroethane, PCE, TCE, and vinyl chloride.

- Aromatic VOCs: benzene, 2-butanone (methyl ethyl ketone (MEK)), naphthalene, 4-methyl-2-pentanone, toluene and methyl tert-butyl ether (MTBE).
- VPH: C_5-C_8 aliphatics.
- EPH: C_{19}-C_{36} aliphatics and C_{11}-C_{22} aromatics.

The COPCs are the chlorinated solvents formerly stored at and delivered to and from the Property, together with their associated breakdown products. Other compounds detected at the Site, including benzene, C_5-C_8 aliphatics, C_{19}-C_{36} aliphatics, C_{11}-C_{22} aromatics, 1,2-dichloroethane, MTBE, naphthalene, and toluene, have not been defined as COPCs. In addition, chloroform, chloroethane, and carbon tetrachloride have been eliminated as COPCs for indoor air, as discussed in Section 11.0.

10.3 Source Characterization

The highest concentrations of COPCs have been measured in soil, soil vapor, and groundwater samples taken at the Property. Documentation submitted to DEP concerning the history of operations at the Property has confirmed that PCE, TCE, and TCA in liquid form were stored and handled at the Property for many years. Over a span of approximately 50 years, ending in 2002, the Property was used as an industrial and laundry chemical supply business. Delivery, storage, loading and unloading of PCE has been documented for much of that period. Likewise, pipe labels and other historical information indicate that TCE and TCA were delivered, stored, loaded, and unloaded on the northern portion of the Property.

10.4 Extent of DNAPL

10.4.1 Assessment of the Presence of DNAPL

Kueper (2008b) conducted an assessment for the likelihood of the presence of PCE, TCE, and TCA DNAPLs, because these compounds are the dominant chlorinated VOCs detected in groundwater at the Site. PCE, TCE, and TCA have been detected in groundwater samples from more than half of the monitoring wells at the Site. Dr. Kueper's report, "Assessment Of DNAPL; Presence And Distribution, 50 Tufts Street Site, Somerville, Massachusetts, RTN # 3-23246," dated June 21, 2008, is in Appendix M.

PCE, TCE, and TCA are common chlorinated VOCs characterized by densities significantly greater than that of water and viscosities similar to that of water. These properties, in conjunction with subsurface investigations, the fact that it has been several years since potential releases likely would have occurred, and consideration of the operational history of the Site, indicate that DNAPL in the subsurface would no longer be moving at the present time. It is very likely that DNAPL present in the subsurface is distributed as both immobile

disconnected blobs and ganglia referred to as residual DNAPL, and as continuous static distributions referred to as connected phase DNAPL.

Dr. Kueper's evaluation considered twelve lines of evidence to assess whether or not DNAPL is present at the Site. Either the direct observation of DNAPL or measured soil concentrations in excess of the value corresponding to a threshold DNAPL saturation (the first two lines of evidence) are conclusive evidence of DNAPL at a site. For the Site, neither of these definitive indicators of DNAPL is present. However, it cannot be concluded that DNAPL is not present at the Site. It is not uncommon to find sites where lines of evidence 1 and 2 are both negative, yet DNAPL is indeed present in the subsurface (consistent with the popular expression that 'DNAPL is usually not visually observed at most DNAPL sites'). In cases where lines of evidence 1 and 2 are both negative, one must consider the remaining ten lines of evidence and decide if a sufficient number of them are satisfied to conclude whether DNAPL is present.

After consideration of the remaining lines of evidence, Dr. Kueper concluded that DNAPL is present in overburden at the Site. The most compelling lines of evidence are associated with the persistent, high groundwater concentrations within and near the Property boundaries.

10.4.2 ***Location of DNAPL***

DNAPL is present in overburden down to the top of bedrock (and possibly in bedrock) at the Site. The DNAPL is not present continuously throughout this volume of porous media, but is rather situated in many discrete lenses and laminations of geologic material. It is not practicable to find the particular lenses and laminations that contain DNAPL. DNAPL has not been visually observed in the monitoring wells or in groundwater or soil samples. Given the lack of DNAPL accumulation in monitoring wells, it can be concluded that the majority of DNAPL exists in the form of disconnected blobs and ganglia of organic liquid referred to as residual DNAPL. Residual DNAPL is immobile as a result of capillary trapping forces. In addition to residual DNAPL, it is possible that isolated zones of continuous DNAPL also exist at the Site. Given the relatively high density and low viscosity of PCE, TCE, and TCA, along with the moderate hydraulic conductivity of the overburden deposits, continuous distributions of DNAPL are no longer migrating and have been stabilized by capillary trapping forces.

With respect to spatial distribution, it is highly likely that DNAPL is present at various locations beneath the Property building footprint. Releases likely occurred at various locations with subsequent subsurface migration along geological bedding planes and conduit backfill, facilitating spreading to various locations beneath the building footprint.

The DNAPL extends into the northern parking lot area beyond monitoring well GEO-1, but not as far as monitoring wells MW202 and MW201. This interpretation is supported by the

fact that groundwater concentrations in GEO-1 have been as high as 121,000 µg/l (sum of PCE, TCE, and TCA), yet concentrations in MW202 and MW201 have not exceeded 64 µg/l (sum of PCE, TCE, and TCA). This abrupt drop in concentrations in the hydraulically upgradient direction indicates that the northern extent of the DNAPL lies between monitoring wells GEO-1 and MW202.

It is likely that DNAPL is present east of the Site beneath Tufts Street from a location south of MW101 to approximately the location of GEO-5, and that it extends eastward from the Site under and beyond Tufts Street. The presence of DNAPL in this area is supported by the persistent high groundwater concentrations in monitoring wells GEO-4 and GEO-5.

It is likely that DNAPL is present south of the building footprint, extending to approximately the location of SHMW2 and possibly further to the south. This interpretation is supported by the persistent high concentrations in monitoring wells MW3, SH-MW1, SH-MW3, and SH-MW2, and the high concentration of PCE in monitoring well MW203 (15,500 µg/l).

It is likely that DNAPL is present in overburden west of the Property building footprint. This interpretation is supported by the high concentrations in monitoring wells GEO-1, MW1, and SH-1, which are located along the western boundary of the Property adjacent to the railway property.

10.4.3 **Composition of DNAPL**

With respect to DNAPL composition, it can be concluded that the northern portion of the Site is impacted by PCE DNAPL, TCE DNAPL, and TCA DNAPL. PCE, TCE, and TCA have been detected in groundwater in the northern portion of the site at up to 37.5%, 20%, and 21.8% of single component solubility, respectively. The southern portion of the Site is impacted by PCE DNAPL, with PCE concentrations in groundwater as high as 25.9% of single component solubility. TCE and TCA concentrations in groundwater in the southern portion of the Site have not exceeded 0.09% and 0.13% of single component solubility, respectively. The persistent presence of TCE and TCA in groundwater indicates that minor quantities of TCE and TCA DNAPL may be present in the southern portion of the Site.

10.4.4 **Stability of DNAPL**

PCE, TCE, and TCA in the form of DNAPLs are present beneath the Property and off-site to the east and west. The DNAPLs are no longer migrating and have reached a stable configuration as a result of capillary trapping forces. The stability of these DNAPL sources is supported by groundwater concentration data collected from monitoring wells within the area of DNAPL occurrence.

10.5 Extent of Chlorinated VOCs in Soil

Five chlorinated VOCs were detected above laboratory RLs in soil samples submitted for laboratory analysis: 1,1-dichloroethane, cis-1,2-dichloroethylene, PCE, TCE and TCA. PCE and TCE are the chlorinated VOCs measured at the highest concentrations and in the greatest number of soil samples. The extent of chlorinated VOCs in soil can be represented by PCE.

The results of chemical testing of soil samples are summarized in Tables 5-1 and 5-2 and shown in Figs. 5-1 and 5-2. The highest concentrations of chlorinated VOCs in soil were detected in samples collected from two borings advanced within the building foot print on the western side of the Property building: SH-1 (12 to 14 ft) at 1,500 mg/kg PCE; and SH-2 (4 to 5 feet) at 1,800 mg/kg PCE. In the northern portion of the Property, outside the building, PCE was measured in soil sample GEO-1 (2 to 4 feet) at 2.45 mg/kg and in GEO-1 (6 to 8 ft) at 8.07 mg/kg. Towards the southern portion of the Property, approximately 100 feet from the building, PCE was measured in soil sample SH-MW2 (15 to 17 ft) at 23 mg/kg.

PCE concentrations in samples collected above the water table at the Property (approximately 10 ft bgs) range from 4.8 to 1,800 mg/kg, while PCE concentrations in samples collected below the water table at the Property range from 0.16 to 1,500 mg/kg.

It is expected that the soil concentrations at the Property have decreased significantly since the historic soil samples were collected due to the ongoing operation of the SSDS and SVE systems.

Chlorinated VOC concentrations in soil decrease with distance from the Property. PCE concentrations in off-Property soil samples collected above the water table range from 0.257 (estimated) to 4.35 mg/kg, while PCE concentrations in off-Property soil samples collected below the water table range from 0.111 to 3.15 mg/kg.

10.6 Extent of Chlorinated VOCs in Groundwater

Eleven chlorinated VOCs were detected above laboratory RLs in groundwater samples collected at the Site: chloroethane, carbon tetrachloride, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, cis-1,2-dichloroethylene, trans-1,2-dichloroethylene, PCE, TCA, TCE, and vinyl chloride. Elevated levels of PCE, TCE, 1,1-dichloroethane, and TCA are present in more than half of the monitoring wells at the Site. PCE is the most dominant, and the extent of chlorinated VOCs in groundwater can be represented by PCE. 1,2-Dichloroethane was eliminated as a COPC as discussed in Section 11.0.

The results of chemical testing of groundwater samples are summarized in Table 5-5 and shown in Figs. 5-4 through 5-6. Fig. 1-2 shows the lateral extent of PCE in shallow

overburden, deep overburden, and bedrock groundwater at a concentration that exceeds the MCP Method 1 GW-2 Standard of 50 µg/l.

10.6.1 Shallow Overburden Groundwater

The shallow overburden groundwater is characterized by the presence of high concentrations of dissolved chlorinated VOCs and DNAPL. The limits of the shallow overburden groundwater plume correspond to groundwater concentrations of PCE that are less than the laboratory RL of 1.0 µg/l. Based on groundwater quality data, the length of the shallow overburden plume is between approximately 825 ft (distance from MW1 to MW116) and approximately 990 ft (distance from MW3 to MW118).

The shallow overburden groundwater plume is bounded approximately by Alston Street, Cross Street, Dell Street, Glen Street, Oliver Street, and Franklin Avenue. The approximate extent of the shallow overburden groundwater plume where PCE exceeds the GW-2 standard of 50 µg/l is also shown on Fig. 1-2.

10.6.2 Deep Overburden and Bedrock Groundwater

Chlorinated VOCs, particularly PCE, have been detected in the groundwater in the deep overburden and bedrock downgradient of the Property. PCE has migrated vertically downward through overburden to bedrock at the Site. In monitoring well couplets and triplets at the Site (e.g., MW118S/T/D, 120D, and 121D), PCE is not detected in the shallow overburden wells of the couplet or triplet, but is detected in the bedrock well. This vertical downward migration is most likely due to recharge (rainfall and snowmelt) into shallow overburden which creates vertical components of groundwater flow.

The lateral limits of the bedrock groundwater plume extend beyond the eastern boundary of the shallow overburden plume to monitoring well clusters MW117 and MW118. This is indicated by the very low concentrations of PCE in groundwater collected from the deep overburden and bedrock wells at these locations. The concentrations of PCE in these wells are significantly attenuated from the center of the plume, and it is unlikely that the contamination extends much beyond where PCE has been measured.

10.6.3 Source and Plume Stability and Plume Response Time

Dr. Kueper conducted an assessment of source stability, plume stability, and plume response time for the Site. Dr. Kueper's report, "Assessment of Source Stability, Plume Stability, And Plume Response Time, 50 Tufts Street Site, Somerville, Massachusetts, RTN 3-23246," dated June 21, 2008, is in Appendix H.

10.6.3.1 Source and Plume Stability

The PCE, TCE, and TCA plumes generally extend to the east of the Site, consistent with known groundwater flow directions. Source and plume stability were evaluated by considering groundwater concentration versus time data for the available monitoring wells. The Mann-Kendall statistical trend test (at both the 80% and 90% confidence levels) was used to evaluate whether PCE, TCE, and TCA concentrations are stable (no trend), increasing, or decreasing in each individual monitoring well.

Based on the Mann-Kendall analysis, subsurface sources of PCE, TCE, and TCA at the Site are stable. The Mann-Kendall analysis indicated that eight of nine source zone monitoring wells exhibited either stable or decreasing PCE concentration trends; nine of nine source zone monitoring wells exhibited either stable or decreasing TCE concentration trends; and nine of nine source zone monitoring wells exhibited either stable or decreasing TCA concentration trends.

Based on the Mann-Kendall analysis, the PCE, TCE, and TCA plumes are stable across the network of monitoring wells in shallow overburden, deep overburden, and bedrock. The Mann-Kendall analysis indicated that 28 of 28 plume monitoring wells exhibited either stable or decreasing PCE concentration trends; 27 of 28 plume monitoring wells exhibited either stable or decreasing TCE concentration trends; and 28 of 28 plume monitoring wells exhibited stable or decreasing TCA concentration trends.

10.6.3.2 Plume Response Time

Plume response time relates to the tendency for chemical concentrations to persist once the source of the plume has been either removed or physically isolated from the plume. Plume response time is a function of both chemical properties, such as the organic carbon partition coefficient, and hydrogeologic properties, such as hydraulic conductivity, hydraulic gradient, fraction organic carbon, distribution of diffusive sinks, and geochemical conditions governing biodegradation. The plume response time is the time required for chemical concentrations to be reduced to target levels following removal or isolation of the source.

It is concluded on the basis of screening level calculations that plume response times in overburden are expected to be slow (more than one hundred years) because of the overall low to moderate hydraulic conductivity, the moderate degree of sorption, and the lack of aggressive biodegradation. Response of the PCE plume to source isolation and/or removal is expected to be slower than that for TCE and TCA because of the initially higher PCE concentrations within the interior of the off-Property plume and the higher retardation factor associated with PCE.

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10.6.3.3 Groundwater Monitoring

Based on Dr. Kueper's evaluation, additional groundwater sampling is planned to confirm the assessment of source stability, plume stability, and plume response time for the Site. The groundwater monitoring wells that we anticipate sampling on a periodic basis are presented in Dr. Kueper's report in Appendix H.

10.7 Extent of Chlorinated VOCs in Subsurface Soil Vapor

The 12 chlorinated VOCs detected in subsurface soil vapor samples at the Site are: chloroethane, carbon tetrachloride, 1,1-dichloroethane, 1,1-dichloroethylene, 1,2-dichloroethane, trans-1,2-dichloroethylene, cis-1,2-dichloroethylene, TCA, 1,1,2-trichloroethane, PCE, TCE, and vinyl chloride. 1,2-Dichloroethane, trans-1,2-dichloroethylene, cis-1,2-dichloroethylene, and 1,1,2-trichloroethane are not considered COPCs. Like soil and groundwater, the extent of chlorinated VOCs in subsurface soil vapor can be represented by PCE.

The results of laboratory analysis of subsurface soil vapor samples are summarized in Table 5-4 and shown in Fig. 5-3.

PCE has been detected at low levels in subsurface soil vapor at Alston Street, Cross Street, Dell Street, Glen Street, Oliver Street, Washington Avenue, the Cobble Hill Apartments on Washington Street, and New Washington Street. The soil vapor plume extends slightly beyond the shallow overburden groundwater plume shown in Fig. 1-2.

10.8 Extent of Chlorinated VOCs in Indoor Air

The eight chlorinated VOCs detected in indoor air samples above laboratory limits in residences and buildings at the Site, excluding the Property building, are: carbon tetrachloride, chloroethane, chloroform, methylene chloride, 1,2-dichloroethane, PCE, TCE, and TCA. However, as described in Section 11.0, chloroethane, chloroform, and methylene chloride were subsequently removed from the indoor air analyte testing list. These compounds, as well as carbon tetrachloride and 1,2-dichloroethane, are not COPCs (Section 11.0). The principal chlorinated VOC measured in indoor air is PCE.

The extent to which migration of COPCs to indoor air constitutes a completed exposure pathway has been thoroughly evaluated. In multiple rounds of indoor air sampling, PCE has not been detected in properties located over the outer portions of the shallow groundwater plume. Likewise, PCE has not been detected in several residences located directly over areas where elevated concentrations of PCE exist in shallow groundwater. Overall, indoor air monitoring data show that the absence or presence of a completed exposure pathway is highly site-specific.

Table 7-1 lists each of the residences and buildings included at the Site and whether or not chlorinated VOCs were detected in indoor air above the laboratory RLs.

10.9 Extent of Chlorinated VOCs in Underground Utilities

The interiors of selected, readily-accessible storm drains and sanitary sewers were evaluated. Potential migration of contaminants in bedding material along the exterior of the underground utilities was evaluated based on contaminant concentrations in soil vapor and groundwater in monitoring wells near the utilities. No indications of significant contaminant migration along the exterior of underground utilities were observed.

Chlorinated VOCs were detected at low concentrations in water collected from catch basins on Washington Street (CB19, CB34, and CB33), located east of the intersection of Joy Street and west of the intersection of New Washington Street. Additionally, liquid collected from two sanitary sewer manholes, SMH44, at the southern end of Franklin Street, and SMH102, in Washington Street at the intersection with Knowlton Street, contained chlorinated VOCs.

Chlorinated VOCs were detected in water samples collected from the three storm water catch basins, CB19, CB33, and CB34 (Fig. 2-1), within the Washington Street alignment, where the street elevation drops beneath an MBCR overpass. The inverts of these structures are located below the overburden groundwater table, and in the (apparent) hydraulically downgradient direction from the Property (Fig. 2-1). The lines connecting these structures were constructed of brick masonry and are likely pervious to groundwater. Thus, in addition to runoff entering the catch basins from the street, groundwater may infiltrate from the surrounding formation.

Flow from the three catch basins is directed westerly along Washington Street to a pump house, located in the vicinity of 120 Washington Street, which is owned and operated by the MBCR. GEI understands from discussions with MBCR employees that the pump house operates during periods of precipitation to abate flooding conditions which tend to occur beneath the railroad overpass. At the time of this report, GEI has been unable to determine the pumping frequency or rates, or where the water pumped from these catch basins discharges. Plans obtained from the MBTA indicate that a 4-inch line connects the pump house to the storm drains located north of the structure along New Washington Street. According to Somerville DPW personnel, the ultimate discharge point of these drains is the Mystic River.

Based on the chemical testing results of the water collected from storm drains and sanitary sewers at the Site, low levels of dissolved phase chlorinated VOCs in groundwater at the Site have infiltrated into both storm drains and sanitary sewers located below the groundwater level in the southern portion of the Site.

Concentrations of site-related contaminants detected in the storm drains are likely to be diluted based on two mechanisms:

- The portion of the storm drain in which chlorinated VOCs were detected is located below the railroad bridge. According to railroad personnel, these drains are only pumped during rain events that would inundate these drains with overland runoff.
- The storm drains are pumped into a large storm drain system that is collecting runoff from a wide area, further diluting effluent from the pump station.

The sanitary sewer effluent is combined with other waste water from the City of Somerville and is treated at the Massachusetts Water Resource Authority (MWRA) Deer Island waste water treatment plant. According to the MWRA's Deer Island treatment plant NPDES permit, there is no discharge limit for individual VOCs, but there is a total VOC limit. In addition, the treatment system currently mixes water from many municipalities and has a capacity to discharge over one billion gallons of water per day.

10.10 Characterization of Background Conditions

GEI conducted outdoor air testing and determined that carbon tetrachloride is ubiquitous in the urban air in this neighborhood in Somerville. The concentrations of carbon tetrachloride detected ranged from 0.69 $\mu g/m^3$ to 0.82 $\mu g/m^3$. Based on these testing results and after discussions with Mr. Michael Tuday, Director of Research and Development at Columbian Analytical in Sima Valley, California, GEI has attributed these detections to background conditions.

11. Method 3 Risk Characterization [310 CMR 40.0900]

11.1 Introduction

AMEC prepared a Method 3 Risk Characterization Report for the Site in accordance with 310 CMR 40.0900 based on the characterization of current and foreseeable Site uses, potential receptors, COPCs, and calculated exposure point concentrations (EPCs). The complete AMEC Method 3 Risk Characterization Report including the risk characterization methodologies and parameters is presented in Appendix M.

The Risk Characterization did not quantitatively evaluate exposures to COPCs in indoor air in buildings that are currently used for residential or educational purposes, because the presence of any COPC above the laboratory RL is being addressed as a CEP, without regard to risk. The Risk Characterization assumes the existence of an EPEM in future occupied buildings, where recommended, at the Site.

For purposes of this Risk Characterization, the Site was divided into six Exposure Areas for the purposes of estimating potential risks: 1) Property, 2) 60 Tufts Street, 3) Tufts Street and MBTA Railroad Area, 4) Alston Street Area, 5) Other Streets Area, and 6) Neighborhood Streets. These areas are shown on Fig. 11-1.

11.2 Current and Reasonably Foreseeable Site Activity and Use

Consistent with the requirements of the MCP (310 CMR 40.0923), the Risk Characterization considered both current and future uses of properties within the Site. The current use of the Property is as a commercial warehouse building that stores automobiles. An active railroad right-of-way is immediately south of the Property. The surrounding land use in the area is mixed residential and commercial. The Capuano Center, an early childhood education center, is located within the Site.

Reasonably foreseeable uses of the Property include commercial and residential. Reasonably foreseeable uses of the remainder of the Site are the same as current use (residential, commercial, and educational).

11.3 Potential Human Receptors

Potential human receptors were identified based on current and foreseeable uses of the Property and residential and commercial properties within the Site.

The potential receptors under current use are:

Off-Property:

- Residents
- Commercial workers
- Landscapers
- Students and teachers at the Capuano Center
- Railroad workers
- Trespassers
- Visitors

The Property:

- Commercial workers
- Landscapers/Maintenance workers
- Utility workers
- Trespassers
- Visitors

The potential receptors under reasonably foreseeable future uses are:

Off-Property:

- Residents
- Commercial workers
- Landscapers
- Utility workers
- Students and teachers at the Capuano Center
- Railroad workers
- Visitors
- Trespassers
- Construction workers

The Property:

- Commercial workers
- Landscapers/Maintenance workers
- Utility workers
- Trespassers
- Residents of future residential development
- Construction workers
- Visitors

11.4 Potential Environmental Receptors

Potential environmental receptors include both terrestrial and aquatic habitats.

No ACECs or Habitats of Rare Wetlands Wildlife are located on-Site or within 500 feet of the Site. Further, the Site is in an urban area, is fully developed, and would not likely represent a potentially significant habitat. Based on the low levels of COPCs in accessible surface soils and the scarcity of open land, the Site does not represent significant habitat or provide for exposures for potential terrestrial receptors.

The closest surface water bodies are the Mystic River, located approximately one mile northeast of the Site and the Charles River, located approximately 1.7 miles south-southeast of the Site. Groundwater samples collected downgradient of the Site indicate concentrations of COPCs below Method 1 GW-3 Groundwater Standards, which are protective of potential surface water impacts. Based on the distance to the nearest surface water receptors and the current levels of COPCs in groundwater, the transport of COPCs in the groundwater to surface water and sediment receptors is not likely. Therefore, the Site does not represent an important habitat for aquatic species.

11.5 Identification of Soil and Groundwater Categories

This section identifies and documents the soil and groundwater categories applicable to the Site, as described in the MCP (310 CMR 40.0930). The soil and groundwater categories are considered general indicators of the potential for exposure to OHM at a site.

11.5.1 Soil Categories

Under the MCP, soil can be classified into one of three categories (S-1, S-2, or S-3). Category S-1 soil represents the highest potential exposure because it assumes the unrestricted use of the soil (i.e., residential), whereas category S-3 soil represents the lowest potential for exposure. The MCP requires that all soil at a site in a future scenario be evaluated as S-1 soil unless an Activity and Use Limitation (AUL) is placed on the Property.

The Site is located in an area of mixed residential and industrial/commercial use. Currently, parts of the Site are covered by buildings and pavement. In other areas, exposed soil is apparent.

The current use of the Site includes commercial, residential, and educational use. Based on potential exposures at the Property for the most sensitive receptor (child trespasser), exposed soil from 0-3 ft bgs is categorized as S-1. Exposed soil at the Property from 3-15 ft bgs is categorized as S-2. Soil at the Property deeper than 15 ft bgs and soil beneath the building is categorized as S-3. Soil located outside the Property boundaries is categorized as S-1 based on potential residential exposures; however, soils located within the street right-of-way are categorized as S-3.

A reasonably foreseeable use of both the Property and off-Property is residential; therefore, the potential exposures for the highest exposed receptor (resident) is soil currently located from 0-15 ft bgs, which is categorized as S-1.

11.5.2 Groundwater Categories

Under the MCP (310 CMR 40.0932), there are three categories for groundwater (GW-1, GW-2, and GW-3) that can apply to a specified volume of groundwater or to an entire aquifer. These groundwater categories were established to identify groundwater associated with the following three distinct types of exposures:

- GW-1 applies to groundwater assumed to be a current or future source of drinking water.
- GW-2 applies to groundwater considered to be a potential source of vapors that could migrate through the soil and concentrate in indoor air of existing, occupied buildings.
- GW-3 applies to groundwater that is assumed to discharge to surface water. All groundwater in Massachusetts is classified as GW-3.

Because these exposures are not necessarily related to each other, they are not mutually exclusive; therefore, more than one category may be applicable to a site and/or different areas of a site.

Groundwater underlying the Site is not a Current or Potential Drinking Water Source Area and as such, is not categorized as GW-1. GW-2 applies to groundwater at the Site where the groundwater containing COPCs is within 30 feet of occupied buildings and where the depth to groundwater is less than 15 feet. Based on this information, the applicable groundwater categories for the Site are GW-2 and GW-3.

11.6 Summary of Analytical Results

The Risk Characterization considered soil, groundwater, soil vapor, ambient air, and indoor air data collected during the Phase II CSA within the Site. The data set for each of the media was evaluated to create a data set for the Risk Characterization that represents current conditions for the Site. The criteria used to create a representative data set are explained in detail in AMEC's Risk Characterization Report (Appendix M).

Data used to estimate potential exposures in the human health Risk Characterization are in Tables 11-1a through 11-1f (soil), Tables 11-2a through 11-2f (groundwater), Tables 11-3a through 11-3f (soil vapor), Tables 11-4a through 11-4f (indoor air), and Tables 11-5a through 11-5f (outdoor air), respectively. The data are presented by Exposure Area.

11.7 Hot Spot Evaluation

Under the MCP (310 CMR 40.0924), hot spots must be considered as distinct exposure points. A hot spot is defined as a discrete area where the concentrations of OHM are

substantially higher than those concentrations in the surrounding area. No hot spots in soil or groundwater have been identified at the Site.

11.8 Compounds of Potential Concern

In accordance with the DEP's "Guidance for Disposal Site Risk Characterization," all chemicals detected at the Site should be considered COPCs and should be carried through the risk assessment process unless one of the following conditions is true:

- The chemicals are present at a low frequency of detection and in low concentrations;
- The chemicals are present at levels that are consistent with "background" concentrations for the area, and there is no evidence that their presence is related to activities at the Site; or
- The chemicals are field or laboratory contaminants.

Using a standard screening process, the following compounds were defined as COPCs for all soil, groundwater, indoor air, excavation/trench air, and outdoor air exposures: 1,1-dichloroethane, cis-1,2-dichloroethylene, 1,1-dichloroethylene, PCE, trans-1,2-dichloroethylene, TCA, TCE, and vinyl chloride. Chloroform, chloroethane, and carbon tetrachloride were also defined as COPCs for soil, groundwater, and excavation/trench air exposures only.

11.9 Exposure Pathways

An exposure assessment under the MCP is the process of identifying the potential for on-Site and surrounding area receptors, both human and environmental, to contact chemicals in the soil and groundwater. Exposure pathways are the mechanisms by which receptors may be exposed to COPCs at the Site.

Where applicable, exposure pathways included incidental ingestion and dermal contact with soil, incidental ingestion, and dermal contact with groundwater, inhalation of airborne constituents in ambient air, inhalation of airborne constituents in excavation air, and inhalation of airborne constituents in indoor air.

The Risk Characterization assumes dewatering will occur prior to future construction activities and that direct contact with groundwater would be minimal, both on-Property and off-Property. Therefore, incidental ingestion and dermal contact with groundwater were not quantitatively evaluated.

It is also assumed that a vapor barrier or other measure will be included as an integral part of the design and construction of any future building on the Property; therefore, indoor air is not a complete exposure pathway for future residential or commercial receptors.

Remedial actions have been conducted at the Capuano Center to mitigate the indoor air exposure. Therefore, no complete indoor air exposure pathway exists for students and teachers at the Capuano Center.

An EPEM will be installed to mitigate indoor air exposure in all residential buildings in which an indoor air exposure is identified. Once the EPEMs are installed, no complete indoor air exposure pathway will exist for residential receptors.

11.10 Identification of Exposure Point Concentrations

The MCP requires that the determination or estimation of EPCs be representative of actual and foreseeable exposures. The development of EPCs often involves statistical analysis of the data. For example, in the MCP, the DEP recommends the use of average concentrations.

Exposure points are defined as locations of potential contact between a receptor and portions/media of a property. The EPC is defined as the chemical concentration in a given medium which a potential receptor may encounter at an exposure point. EPCs were developed for each exposure medium at the Site.

Six exposure points were evaluated in the Risk Characterization: 1) Property, 2) 60 Tufts Street, 3) Tufts Street and MBTA Railroad Area, 4) Alston Street Area, 5) Other Streets Area, and 6) Neighborhood Streets.

The Risk Characterization performed a Worst Case assessment for most exposures. To calculate the off-Property soil, soil vapor, and groundwater EPCs, the maximum soil, and the maximum temporal average of each groundwater and soil vapor monitoring point was used for each COPC for each of the five off-Property Exposure Areas. For the commercial off-Property buildings a temporal average indoor air EPC was calculated for each building. For a soil EPC on the Property, an average soil sample concentration was calculated using data collected after the SVE system was operating. For a groundwater EPC on the Property, the maximum temporal average of each groundwater monitoring well point on the Property was used. Two post-mitigation indoor air EPCs were calculated for the Property building: one spatial average EPC was calculated for the north and south office areas and one spatial average EPC was calculated for the warehouse and garage area. Soil vapor samples were not collected on the Property. An average outdoor air EPC was developed for each of the six Exposure Areas.

The arithmetic mean of the measured concentrations was calculated assuming that non-detected compounds were present at one-half the laboratory RL. If a COPC was not detected in a given Exposure Area, then one-half the lowest laboratory RL was used as the EPC for that COPC.

A summary of soil, groundwater, soil vapor, indoor air, and outdoor air EPCs used in the Risk Characterization are in Tables 11-6a through 11-6f. EPCs for indoor air at current commercial buildings and potential future residents are in Table 11-6g.

11.11 Risk of Harm to Human Health

The risk of harm to human health is evaluated by combining the results of the exposure assessment and the toxicity assessment for each COPC to estimate the potential for noncarcinogenic and carcinogenic human health effects from exposure to that compound.

The total noncarcinogenic Hazard Indices (HIs) for all evaluated scenarios are at or below DEP's target HI of 1. These results indicate that a condition of NSR exists for non-cancer effects of current and future exposures at each Exposure Area within the Site. The total Excess Lifetime Cancer Risks (ELCRs) for all evaluated scenarios are at or below DEP's target risk level of $1x10^{-5}$. The ELCR calculations are based on conservative exposure durations and exposure point concentration assumptions. These results indicate that a condition of NSR exists for carcinogenic effects of current and future exposures at each Exposure Area within the Site.

11.12 Risk of Harm to Public Safety and Welfare

The risk of harm to safety and public welfare was evaluated in accordance with 310 CMR 40.0994. No overt situations posing a threat of physical harm or bodily injury exist, nor have persistent odors associated with the release been reported. As such, conditions at the Site do not pose a threat of physical harm or bodily injury, and present no dangerous or nuisance conditions.

As part of the public welfare evaluation, soil and groundwater EPCs across the Site were compared to upper concentration limits (UCLs). Groundwater and soil EPCs are below the UCLs.

11.13 Risk of Harm to the Environment

Risk to the Environment was evaluated in accordance with DEP guidance ("Method 3 Environmental Risk Characterization" (MassDEP, 1996)) and the MCP. Based on the terrestrial and aquatic habitat evaluation, no "potentially significant exposures" to identified environmental receptors from COPCs likely exist, and a Stage II Environmental Risk Characterization is not necessary. In addition, conditions at the Site pose NSR to the Environment.

11.14 Uncertainty Analysis

Certain assumptions within the risk assessment process must be made due to a lack of absolute scientific knowledge. Some of the assumptions are supported by considerable scientific evidence, while others have less support. Every assumption introduces some degree of uncertainty into the risk assessment process. Conservative assumptions are made throughout the risk assessment to ensure that the health of local residents and the environment are protected. When all of the assumptions are combined, it is much more likely that the actual risks, if any, are over-estimated rather than under-estimated.

The uncertainties associated with each stage of AMEC's Method 3 Risk Characterization are discussed in Section 7.0 of the risk characterization included in Appendix M. AMEC concluded that risk was conservatively estimated at each stage.

11.15 Conclusions

A site-specific Method 3 Risk Characterization was performed to evaluate the potential harm to human health and the environment. However, risk calculations were not performed for exposures to COPCs in indoor air in residences or the Capuano Center because the detection of chlorinated VOCs associated with the Site in the occupied living space of a residence or the Capuano Center is a CEP being addressed without regard to risk.

The potential exposure pathways evaluated at the Site include:

- Ingestion and dermal contact with soil by a current and future commercial worker, resident, trespasser, visitor, student, teacher, railroad worker, and landscaper; and a future utility worker and construction worker.
- Ingestion and dermal contact with groundwater by a future utility worker.
- Inhalation of air in an excavation by a future utility worker and construction worker.
- Inhalation of indoor air by current and potential future occupants of commercial buildings.
- Inhalation of outdoor air by a current and future commercial worker, resident, trespasser, visitor, student, teacher, railroad worker, and landscaper.

The results of the Method 3 Risk Characterization demonstrate the Site poses a level of NSR to current and future receptors assuming the indoor air exposure pathway is mitigated as recommended to address CEPs.

12. Representativeness Evaluation and Data Usability Assessment

12.1 Introduction

A Representativeness Evaluation and Data Usability Assessment (REDUA) is required by the MCP (310 CMR 40.1056(2)(k)) to support an RAO. This interim REDUA is being prepared in conjunction with the Phase II Report due to the large amount of data collected and the expectation that multiple RAO statements will be prepared for the Site. This interim REDUA incorporates guidance provided by DEP Policy WSC-07-350. It provides an evaluation that demonstrates the adequacy of the spatial and temporal data sets used in the Phase II CSA and Risk Characterization and makes conclusions on the accuracy, precision, and sensitivity of the data used.

12.2 Site Specific List of Chlorinated VOCs

During IRA and Phase II activities, GEI has submitted soil vapor, indoor and outdoor air, and selected soil and groundwater samples to Accutest for chemical testing of a site-specific list of chlorinated VOCs by EPA Method TO-15 (Table 4-9).

At the start of IRA and Phase II activities, the EPA Method TO-15 list was modified to report the same analytes reported by DEP during the indoor air testing conducted in 2005. In addition to the compounds listed in Table 4-9, the site-specific analyte list also included methylene chloride, chloromethane, and chloroform.

For samples collected after July 31, 2006, the analyte list was modified to remove methylene chloride because this compound was consistently detected in laboratory blanks and is not associated with the Site. Chloroform and chloromethane were also removed from the analyte list for these samples because the compounds are not associated with the Site.

The site-specific list was slightly altered after installation of the SSDS at the Capuano Center in February 2007. Following the installation of the SSDS at the Capuano Center, the initial laboratory analysis of the effluent was submitted for analysis of acetone, MEK (2-butanone), and tetrahydrofuran in addition to the site-specific list of chlorinated VOCs. The source of these additional compounds was the glue used to connect the polyvinyl (PVC) pipe during construction of the SSDS. They contributed to the total VOC concentration of the effluent that was measured by the PID. Therefore, the data were used to correct the total VOC concentration in the effluent to represent only chlorinated VOCs being extracted from the subsurface and discharged to the atmosphere.

A similar alteration to the site-specific list of chlorinated VOCs was made following the installation of the SSDS at the Property in May 2007 to correct for the total VOC concentration in the effluent. In this case, the system influent and effluent were tested for the full list of analytes specified by EPA Method TO-15.

12.3 Representativeness Evaluation

The Representativeness Evaluation evaluates the spatial and temporal data sets. It addresses whether the information adequately characterizes the disposal site and supports the CSM. The Representativeness Evaluation should address the:

- CSM
- Use of Field/Screening Data
- Sampling Rationale
- Number, Spatial Distribution and Handling of Samples
- Temporal Distribution of Samples
- Completeness
- Inconsistency and Uncertainty
- Information Considered Unrepresentative

12.3.1 Conceptual Site Model

A CSM for the Site is presented in Section 1.6.

12.3.2 Use of Field/Screening Data

Field screening was used as an investigative tool during subsurface field activities and a diagnostic tool for the design and operation of SSDS and SVE systems located at the Site.

PID screening data were collected during subsurface activities such as drilling activities. Soil samples were screened for VOCs in the field using a PID and the jar headspace method and the results were recorded on boring logs. Samples with higher screening levels based on PID readings were typically selected for submittal for laboratory testing.

DEP installed three well points (MW DEPA – MW DEP C) at the Capuano Center in May 2007 and collected groundwater samples for analytical screening of chlorinated VOCs on May 30, 2007. GEI used this screening data to locate well couplets MW120 and MW119.

PID screening was used during various diagnostic tests associated with the design and startup of the SSDS at the Property and the Capuano Center, and the SVE system at the Property, along with monitoring of ongoing operations of the systems. PID screening has been used as

a tool in vapor intrusion evaluations, for example, to identify potential pathways from under building slabs into indoor air. PID screening also has been used to document total VOC concentrations extracted by the SSDS at the Property and the Capuano Center. PID screening is used to monitor VOC concentration in the combined influent and the discharge from the off-gas treatment system, and also between the lead and polish carbon units (i.e., lead tank effluent).

12.3.3 Sampling Rationale and Spatial Distribution

To characterize the Site and evaluate potential risk, GEI collected soil, groundwater, soil vapor, and indoor air, as well as water from storm drains and sewers. This section discusses the sampling locations and depths, along with the density and spatial distribution.

12.3.3.1 Groundwater

To delineate the extent of the disposal site, GEI installed groundwater monitoring wells in the overburden (fill, silt, and deep overburden) and bedrock. Groundwater samples were collected in each geologic unit. At the outer portions of the disposal Site, PCE was not detected above laboratory RLs in the shallow monitoring wells and was detected at very low levels in the deep overburden and bedrock wells. These data points adequately define the Site boundary.

GEI obtained groundwater samples and measurements from existing groundwater monitoring wells on the Property and on Tufts Street. One well, SH-MW1, was abandoned because it was screened across the overburden and bedrock contact. GEI supplemented the existing wells with 32 additional wells, both on the Property and at other locations at the Site.

12.3.3.2 Soil

Soil samples were collected at the time of groundwater monitoring well installation, typically based on PID field screening, to evaluate the presence of chlorinated VOCs in soils. Surface soil samples also were collected across the Site, including from the community gardens at the Capuano Center, to evaluate the potential for direct contact with contaminated soils by neighborhood residents. Soil samples were collected from discrete locations, and no compositing was performed.

Soil samples have been collected at the Property and from beneath the basement or foundation slab in selected residential buildings to characterize the material for off-site disposal. At the Property, GEI generally relied on the existing soil testing results collected prior to its investigation on the Property. However, the soil samples collected at the Property are from the vadose zone and are likely no longer representative of current Site conditions.

The SSDS and SVE systems have extracted substantial contaminant mass from vadose zone soils and, as a result, concentrations of chlorinated VOCs have decreased.

12.3.3.3 Soil Vapor

Subsurface soil vapor samples were collected to assess volatilization of chlorinated VOCs from groundwater into soil vapor. The samples were collected across the Site, in the vadose zone, typically coincident with shallow groundwater monitoring locations. Subsurface soil vapor samples were collected over a 1-hour period using 6-liter Summa canisters and submitted to Accutest for laboratory analysis of the site-specific list of chlorinated VOCs by EPA Method TO-15 (Table 4-9).

Sub-slab soil vapor samples also were collected beneath residences and commercial buildings to evaluate vapor intrusion as a potential exposure pathway. If indoor air testing previously had confirmed a completed vapor intrusion pathway, sub-slab vapor testing was not conducted.

Subsurface and sub-slab soil vapor samples were collected to compare with PID screening that was done as part of the various diagnostic tests associated with the design and startup of the SSDSs at the Property and the Capuano Center, and the SVE system at the Property, along with ongoing operations of those systems.

12.3.3.4 Indoor and Outdoor Air

Indoor air testing has been conducted at the Property, at residences and commercial buildings at the Site, and at the Capuano Center. Indoor and outdoor air samples were collected over a 4-hour period using 6 liter Summa canisters and submitted to Accutest for laboratory analysis of the site-specific list of chlorinated VOCs by EPA Method TO-15 (Table 4-9). At the request of the home owner, GEI collected an indoor air sample at 95R Franklin Street over an 8-hour period.

The Property

Indoor air testing was conducted at the Property in connection with the design, diagnostic testing, and operation of the SSDS and SVE systems.

Residences and Commercial Buildings

Indoor air sampling was conducted in the residences along the southern portion of Tufts Street as part of a year-long monitoring program. The indoor air testing confirmed a completed vapor intrusion pathway and implementing an EPEM in these seven residential buildings was recommended. Indoor air samples were collected in residences and commercial buildings where the sub-slab soil vapor testing results did not trigger installation

of an EPEM based on pre-established criteria. Indoor air samples were collected in the basements and first floors. If indoor air testing identified a CEP in a residence, then an EPEM was recommended. If indoor air testing did not result in the detection of measurable chlorinated VOCs above the laboratory RL in an occupied living space in a residence (a CEP) or at a level of significant risk in a commercial building, then additional indoor air testing was conducted. Multiple rounds of indoor air testing have been conducted at residences and commercial buildings where chlorinated VOCs have not been detected above laboratory RLs.

Indoor air testing has also been conducted to confirm the efficacy of an EPEM. A minimum of two rounds of indoor air testing has been conducted at residences where an SSDS or vapor barrier and ventilation system has been installed.

Indoor air testing at two residences (95R Franklin Street and 95 Franklin Street) indicated that site conditions were not conducive to use of an SSDS as a mitigation measure. A vapor barrier and venting system has been installed at 95R Franklin Street and is also planned for 95 Franklin Street. Indoor air testing conducted at 95R Franklin Street following completion of vapor barrier and venting system installation demonstrated its effectiveness.

Capuano Center

Monthly indoor air testing has been conducted at the Capuano Center since February 2007, demonstrating the effectiveness of the SSDS. The samples are collected in the classrooms where chlorinated compounds were initially detected.

12.3.3.5 Outdoor Air Samples

Outdoor air samples were collected to evaluate ambient air conditions. Samples were collected across the neighborhood.

12.3.4 Storm Drains and Sewers

Water and wastewater samples were collected from storm drains and sanitary sewers, respectively, to evaluate the potential for contaminated groundwater to enter underground utilities. Samples were collected across the Site.

12.3.5 Temporal Distribution of Samples

12.3.5.1 Groundwater

GEI conducted quarterly groundwater sampling rounds at the Site beginning in May 2006. Other groundwater sampling rounds have been conducted since 2002. The results of groundwater quality measurements in all quarters indicate that the distribution of

contaminants in groundwater is stable across the network of monitoring wells in both the overburden and bedrock, regardless of seasonality. GEI expects to conduct additional quarterly sampling to establish a longer record of groundwater results, particularly in more recently installed groundwater monitoring wells.

12.3.5.2 Soil

Contaminants in soil typically do not fluctuate with seasonal conditions and therefore temporal sampling of soil is not warranted.

12.3.5.3 Soil Vapor

GEI conducted quarterly subsurface soil vapor sampling rounds in wells installed at the Site beginning in January 2007. Sufficient quarterly sampling has been conducted to measure seasonal variability in soil vapor. GEI will discontinue subsurface soil vapor sampling with the completion of Phase II activities.

GEI typically collected one soil vapor sample from beneath the slab of residences and commercial buildings at the Site. Conducting only one sub-slab soil vapor test was appropriate since the test was used primarily as a screening tool, and either mitigation or indoor air testing was recommended based on the test results.

12.3.5.4 Indoor Air and Outdoor Air

Indoor air testing has been conducted at the Property, at residences and commercial buildings at the Site, and at the Capuano Center as described below.

The Property

Following the installation of the SSDS and SVE systems at the Property, GEI collected two rounds of indoor air samples to demonstrate the effectiveness of the mitigation. The samples were collected during winter conditions; one with the building's heating system off and one with the heating system on. Two additional samples will be collected in 2008 to evaluate potential seasonal fluctuations.

Residences and Commercial Buildings

If indoor air testing at a residence resulted in the detection of measurable concentrations of chlorinated VOCs in occupied living space, it was considered a CEP and mitigation was recommended. Additional temporal testing to evaluate seasonal influences on the vapor intrusion pathway therefore was not necessary.

If indoor air testing at a residence did not result in the detection of measurable concentrations of chlorinated VOCs above laboratory detection limits, additional indoor air testing was performed to evaluate seasonal influences on the potential vapor intrusion pathway. For the residences and commercial buildings located at the outer edges of the plume, three rounds (fall, winter and summer) of indoor air testing are sufficient to demonstrate that there is an incomplete vapor intrusion pathway, and no additional actions or testing are required.

For residences and commercial buildings located in proximity to elevated concentrations of PCE in shallow groundwater in which indoor air testing did not result in the detection of measurable concentrations of chlorinated VOCs above the laboratory RL, three rounds (fall, winter and summer) of indoor air testing are being performed. Following the completion of the third round, additional sampling will be conducted during the winter of 2009 and 2010 to evaluate whether fluctuations in seasonal effects occur and affect the vapor intrusion pathway.

At commercial buildings where measurable concentrations of chlorinated VOCs have been detected above laboratory RLs, but not at a concentration that would pose an imminent hazard or significant risk, a minimum of three rounds of indoor air samples have been or will be collected to evaluate the effects of seasonal variation on the vapor intrusion pathway.

Following the installation of EPEMs at residences and commercial buildings at the Site, GEI conducted a minimum of two rounds of indoor air testing, at least one of which was in a winter month. GEI did not conduct indoor air testing at 103 Washington Street since it is an auto repair business that uses solvents; rather, the sub-slab pressure has been monitored to demonstrate the effectiveness of the SSDS in cutting off the vapor intrusion pathway.

Capuano Center

Following the installation and startup of the SSDS at the Capuano Center in February 2007, GEI collected indoor and outdoor air sampling monthly in classrooms where chlorinated VOCs were initially detected. The sampling was at a sufficient frequency to demonstrate the effectiveness of the system under all seasonal conditions.

12.3.5.5 Storm Drains and Sewers

Storm drain and sanitary sewer catch basins and manholes within the Site were surveyed to determine their elevation. These elevations were compared with historically high groundwater levels to determine if the underground utilities have the potential to intercept the groundwater table. Based on these evaluations, GEI collected water samples from the utilities that have the potential to be impacted by contaminated groundwater. Water from the storm drain catch basins was sampled during a non-storm event because this represents the potential for the highest ratio of groundwater to storm water run-off. Similarly, water from

the sanitary sewer manholes was sampled during a weekday when GEI anticipated fewer people would be home using water, thereby causing the least dilution of potentially infiltrating groundwater with wastewater. These evaluations were conservative relative to the potential presence of chlorinated VOCs, and therefore, do not require additional sampling rounds.

12.3.6 Field Completeness

A comprehensive analytical data set for this Site is available and consists of soil, groundwater, soil vapor, outdoor air, and indoor air data. However, a few data gaps exist and are described below.

12.3.6.1 Groundwater

The available groundwater data is adequate to define the extent of the chlorinated VOCs in overburden and bedrock and the potential risks posed by the Site. The data set is also adequate to establish the groundwater plumes (PCE, TCE, and TCA) are stable; however, GEI expects to conduct additional quarterly sampling to establish a longer record of groundwater results, particularly in more recently installed groundwater monitoring wells.

12.3.6.2 Soil

Sufficient soil data have been collected to characterize the Site and evaluate potential risks posed by the Site; therefore, the soil data set is complete.

12.3.6.3 Soil Vapor

Sufficient subsurface soil vapor data have been collected (Table 5-3) to characterize the Site and evaluate potential risks posed by the Site; therefore the subsurface soil vapor data set is complete.

The first step in the process to evaluate potential vapor intrusion pathways at residences and commercial buildings at the Site was to collect sub-slab soil vapor samples. GEI could not obtain contact information for the owners at four residential properties and was denied access to four other residential properties. The absence of sub-slab soil vapor at these locations is a data gap. GEI provided these property addresses and known owner information to DEP for further action. The properties are identified in Table 7-1.

12.3.6.4 Indoor Air and Outdoor Air

In general, sufficient indoor air data has been collected to characterize the Site and to evaluate potential risks or CEPs at the Site. However, additional indoor air testing data will

continue to be collected to confirm the evaluations conducted to date. In addition, two property owners denied GEI access to undertake the evaluation process.

After collecting sub-slab soil vapor samples at 12 Alston Street, the owner denied access for conducting indoor air sampling. After collecting sub-slab soil vapor and one round of indoor air samples, the owner of 156 Glenn Street/21 Morton Street denied access for conducting additional indoor air testing. Although the test results to date at these locations do not indicate the need for mitigation, three rounds of indoor air testing were not collected in accordance with the evaluation process and it is therefore considered a data gap. GEI has provided the names and addresses of these property owners to DEP.

Sufficient outdoor air samples have been collected to evaluate ambient conditions in the neighborhood; therefore, the outdoor air data set is complete.

12.3.6.5 Storm Drains and Sewers

As described in Section 4.11, the available storm drain and sewer data are adequate to evaluate if they are pathways for the migration of chlorinated VOCs; therefore, the storm drain and sewer water data set is complete for this purpose. However, additional evaluations will be conducted as described in Section 9.6.

12.3.7 Data Inconsistencies and Uncertainty

12.3.7.1 Groundwater

The groundwater quality and elevation data collected at MW110 are anomalous when compared with other data collected at the Site. The anomalous conditions at MW110 are believed to be related to a leaking water line or other source of water in the immediate vicinity of this well. The groundwater elevations at this location are high, creating an apparent mound in the water table. These groundwater elevations have not been used in developing groundwater contours at the Site. In addition, the groundwater quality data - mostly non-detects - appears to be inconsistent with data from other nearby groundwater monitoring wells. However, the anomalous condition at MW110 does not affect any substantive conclusions regarding the nature, extent, risks, or feasible mitigation measures related to contamination at the Site.

GEI began collecting groundwater data in May 2006. Groundwater data collected by other consultants at the Site prior to 2006 were not used in the Risk Characterization since sufficient, more recent groundwater quality data existed.

12.3.7.2 Soil

Historic and recent soil data were used to characterize and evaluate potential risk at the Site. However, use of the historic soil data at the Property is conservative; the soil samples were collected from the vadose zone and are likely no longer representative of current Site conditions. Due to the operation of the SSDS and SVE systems, the concentrations of chlorinated VOCs at and in the vicinity of the Property have decreased and are likely to continue decreasing.

The installation of the SVE at the Property generated approximately 30 tons of excess soil. This soil was sampled and submitted for laboratory analysis of soil disposal parameters. The soil has been removed from the Site and the associated data are not considered representative of existing conditions. The data, therefore, were not used in the Risk Characterization.

Similarly, approximately 5.5 cubic yards (cy) of soil were excavated and removed during installation of the EPEM at 95R Franklin Street. Soil samples were collected for soil disposal. The soil has been removed from the Site and the associated data are not considered representative of existing conditions. The data, therefore, were not used in the Risk Characterization.

12.3.7.3 Soil Vapor

The subsurface soil vapor measurements of PCE and TCE for well MW111 on October 9, 2007 were an order of magnitude higher than the previously-measured maximums for these compounds (Table 5-3). Comparison of these data to the rest of the data set did not reveal any temporal trends that would explain this data. After a careful review of the raw data and discussions with the analytical laboratory (Accutest New England), no apparent error was uncovered. These data were considered inconsistent but were still used in the Risk Characterization, which was conservative.

Sub-slab soil vapor testing results showed substantial variability. Two sub-slab soil vapor test results from beneath the same residence or commercial building could vary significantly. A recommendation for installing an EPEM was reached based on the higher of the two sub-slab soil vapor test results. At several locations located in proximity to elevated concentrations of PCE in groundwater (19, 23, 27, and 29 Knowlton Street), concentrations of PCE in sub-slab soil vapor samples were below the 10 mg/kg cut-off. At those locations, however, GEI did not assume the absence of a vapor intrusion pathway, but collected indoor air samples for confirmation.

12.3.7.4 Indoor Air and Outdoor Air

At the Capuano Center, on January 6, 2007, GEI and EH&E conducted contemporaneous sampling of indoor air using two different methods. Samples were collected in 6-liter

Summa canisters (collected over a 4-hour period) and as grab samples collected in Tedlar bags. The Summa canisters were submitted for laboratory analysis and the Tedlar bags were analyzed with a laboratory grade gas chromatograph (GC) in an on-Site mobile lab. The grab samples were collected with the intent to get a "real time" measurement of the concentration of PCE in the classrooms using the mobile lab. The results from the mobile lab, however, were not consistently confirmed by the laboratory testing. The mobile lab data, therefore, were not used.

Following the startup of the SSDS at the Property, GEI conducted indoor air sampling there on May 1, 2007 and May 14, 2007. These samples were affected by residual PCE that was subsequently discovered in several pipes hanging in the rafters of the building and removed on June 21, 2007. Therefore, the results of the first two rounds represented a combination of potential sources inside and outside the building. Therefore, these data were not used.

Approximately 30 tons of contaminated soil was stored in roll-offs at the Property as part of the installation of the SVE system. On August 28, 2007, GEI collected indoor and outdoor air samples when the roll-off was still on the Property. These samples were affected by the contaminated soil being stored on the Property and were neither consistent with the results of subsequent rounds of indoor air testing nor representative of normal operating conditions. Therefore, these data were not used.

12.3.7.5 Flux Boxes

At the Property, during August 2007, EH&E conducted flux box tests within the building to evaluate the potential for soil vapor intrusion along the floor-wall interface. They used Draeger tubes to generate qualitative data on the PCE content of the flux boxes. Because the data generated was only qualitative, it was not used.

At 95 Franklin Street, during September 2007, EH&E conducted flux box tests to evaluate if vapor intrusion through the basement walls was an exposure pathway for chlorinated VOCs into indoor air. Due to uncertainty regarding the integrity of the seal between the flux box and the building wall, as well as the methodology used to sample the flux box, these data were not used.

12.3.7.6 Storm Drains and Sewers

There were no significant inconsistencies or uncertainties associated with the water samples collected from storm drains and sanitary sewers during the utility evaluation.

12.4 Data Usability

The MCP related activities performed, media collected, and dates of sample collection are described in detail in Sections 4.0 through 8.0, and in the associated Tables and Figures.

12.4.1 Appropriateness of Analytical Methods

For analytical methods, the laboratory's performance was monitored using the appropriate quality control samples to assess Analytical Accuracy and Analytical Precision. Analytical Accuracy was monitored in the laboratory through continuing calibrations, initial calibration verification samples, and laboratory control spikes (blank spikes), or other samples as specified by the method. The laboratory monitored Analytical Precision by analyzing laboratory duplicates, laboratory control spike duplicates, or other samples as required by the method. In addition, GEI submitted field duplicates and trip blanks, where appropriate, as an additional check on laboratory performance. All data, including quality control data, were independently reviewed by analytical chemists unaffiliated with the laboratory.

The data results tables, Tables 5-1 through 5-6, 6-1 and 6-2, 7-2 through 7-63, and 8-1 and 8-2 of this report, list the analytical methods used on the Site. The Methods used are appropriate for the contaminants of concern at the Site. The data GEI collected were analyzed by the methods specified in the CAM for each environmental medium except soil vapor, indoor air, and outdoor air. There is no CAM method for these media. GEI used EPA Method TO-15.

The soil and groundwater data tables include historic data from samples collected by SHA in June 2002 and July 2002, and from samples collected by GeoInsight in August 2004.

The data from SHA were collected before the CAM was put into effect (August 1, 2003). The samples in question were analyzed by AWHL for VOCs according to EPA SW846 Methods 5035/8260B, following the procedure for high-level soils, and for VPH and EPH. The laboratory analyzed the appropriate quality control samples necessary for "Presumptive Certainty" under the CAM as specified by the method, including method blanks as a measure of sensitivity, laboratory control spikes, and matrix spikes as a measure of analytical accuracy, and laboratory duplicates and matrix spike duplicates as a measure of analytical precision. All analyses were spiked with the required surrogate compounds to measure extraction efficiency. All quality control sample percent recoveries were within the supplied control limits, establishing the quality of the data. Therefore, the data as reported meet the "Presumptive Certainty" standard and were included in the decision making process.

The data from GeoInsight are from samples collected and analyzed in August 2004 for VOCs according to EPA SW846 Method 8260B. Soil samples were prepared according to SW846 Method 5030 before being analyzed for VOCs by Method 8260B. No MCP forms were included in the data package received, but all required quality control samples necessary for "Presumptive Certainty" under the CAM were prepared and analyzed with acceptable results. Therefore, the data as reported meet the "Presumptive Certainty" standard and were included in the decision making process.

GEI reduced the full lists of VOCs in soil and water listed in EPA SW846 Method 8260 and in air by EPA Method TO-15 to a site-specific list of chlorinated VOCs based on results of an initial survey and Site history. A more detailed discussion of the site-specific list of VOCs is in Section 12.2.

Typically, soil vapor samples were analyzed for a site-specific list of chlorinated VOCs by EPA Method TO-15. Following the installation of the SSDS at the Capuano Center, the initial laboratory analysis of the effluent was submitted for analysis of acetone, MEK (2-butanone), and tetrahydrofuran in addition to the site-specific list of chlorinated VOCs. The source of these additional compounds was the glue used to connect the PVC pipe during construction of the SSDS. They contributed to the total VOC concentration of the effluent that was measured by the PID. Therefore, the data were used to correct the total VOC concentration in the effluent to represent only chlorinated VOCs being extracted from the subsurface.

12.4.2 Appropriateness of Reporting Limits

For the purposes of Risk Characterization, the analytical data were reported to the method detection limit (MDL), not just the RL, which is higher than the MDL. Data reported to the MDL are flagged on the laboratory data sheets and report tables with a "J." These data were used in the decision making process.

12.4.3 Data Review and Validation

Based on the Representativeness Evaluation, GEI evaluated the analytical data quality of the groundwater, soil, soil vapor, and indoor and outdoor air samples results in Tables 5-1 through 5-6, 6-1 and 6-2, 7-2 through 7-63, and 8-1 and 8-2. GEI reviewed the data internally according to GEI SOP RE-08, using the DEP Bureau of Waste Site Cleanup document WSC#02-320: Compendium of Quality Assurance and Quality Control Requirements and Performance Standards for Selected Analytical Methods (CAM) and Region I, EPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses, December, 1996, as guidance.

GEI also arranged for third-party data validators to provide an independent assessment of data quality. This data review assessed compliance with the following documents: Quality Assurance Project Plan (QAPP) – Indoor Air Testing, Tufts Street, Somerville, Massachusetts, prepared by GEI, April 6, 2006; EPA Method TO-15, Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS), January 1999, EPA/625/R-96/010b; Massachusetts Department of Environmental Protection, Indoor Air Sampling and Evaluation Guide, WSC Policy # 02-430, April 2002; and USEPA Contract Laboratory

Program National Functional Guidelines for Organic Data Review Publication EPA A540/R-99/008, October 1999.

The internal and third party data reviews assessed the data reported by the laboratory for extraction efficiency (surrogate recovery), analytical accuracy (continuing calibrations, laboratory control spikes, etc.), and analytical precision (laboratory duplicates, laboratory control spike duplicates, field duplicates, etc.). Based on the internal GEI data review and the EPA Tier II-type data review performed by the data validators, GEI applied data qualifiers to the data in the tables as warranted.

12.4.4 Field Data Usability

In general, GEI used field data for screening purposes only. When necessary, field data were corroborated through the collection and analysis of analytical samples. Field data were not subject to the same review and validation processes as analytical data.

12.4.5 Rejected Data

Some analytical data were rejected, and therefore not considered in the decision making process. This section discusses the rejected data and the rationale for not using these data.

12.4.5.1 Groundwater Data

Analytical results for 1,4-dioxane in groundwater samples collected on October 9, 2006 were rejected by the outside data validator due to gross exceedance of the minimum response factor criteria as specified in EPA SW846 Method 8260.

12.4.5.2 Soil

No soil data were rejected.

12.4.5.3 Soil Vapor

No soil vapor data were rejected.

12.4.5.4 Indoor Air and Outdoor Air

A duplicate air sample was collected in Room 138 during each monthly indoor air sampling event at the Capuano Center. Each set of duplicate air samples was created by using a T-splitter and tubing attached to two canisters so that both canisters were drawing air from the same sample port.

The duplicate air samples (i.e., both canisters from each event) were submitted blind to Accutest for testing. The purpose of these duplicates was to evaluate the ability of the

laboratory to accurately replicate testing results. The calculated relative percentage difference (RPD) between the duplicate samples for each sampling event between October 2007 and May 2008 was within the acceptable limit of 25 percent for all but the October 8, 2007 and February 19, 2008 samples.

The RPDs for the duplicate samples collected in Classroom 138 on October 8, 2007 and February 19, 2008 were not within the acceptable limit of 25 percent. The sample and duplicate sample were collected using a stainless steel T-splitter attached to the two sample canisters so that both canisters were drawing air from the same sample port. The laboratory detected PCE at a concentration of 0.22 ppbv (1.5 $\mu g/m^3$) and 0.27 ppbv (1.8 $\mu g/m^3$) in the October and February duplicate samples, respectively; however, the laboratory did not detect PCE above the laboratory RL in the non-duplicate samples collected on these dates in Classroom 138.

According to the Region I, EPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses (December 1996), a data reviewer can use professional judgment when evaluating field duplicates where one sample is a non-detect and the other sample is a positive detect at less than twice the RL, given the increased variability that occurs close to the RL. Based on this guidance, the difference between the two samples reported above is attributed to increased method variability close to the RL, and no qualifiers were applied to the data.

In January 2007, two Summa canisters were collected in duplicate via a splitter from Room 138 of the Capuano Center. One canister (ID: M151) was sent to Accutest New England (Accutest) and one canister (ID: M039) to AWHL for analysis by EPA Method TO-15 for selected chlorinated hydrocarbons. The concentrations of PCE (58.3 $\mu g/m^3$) and TCE (7.15 $\mu g/m^3$) in the canister analyzed by AWHL were more than two times higher than the results measured by Accutest (PCE = 20 $\mu g/m^3$; TCE = 3.1 $\mu g/m^3$). To confirm the initial results, GEI sent canister M039, originally analyzed by AWHL, to Accutest for reanalysis. The reanalysis results were nearly identical to those from the original analysis performed by Accutest on canister M151. AWHL subsequently contacted GEI to inform us that there was an error specific to its original sample analysis; the analyst performing the work had used a linear regression to quantify the samples instead of average response factors, which is AWHL's preferred method of quantification. Due to problems with the data quantification, GEI rejected the data from AWHL.

12.4.5.5 Storm Drains and Sewers

No storm drain or sewer data were rejected.

12.4.6 Presumptive Certainty

GEI data used in this report meet the method performance standards and quality control requirements for "Presumptive Certainty" as specified in DEP CAM IV A, Section 2.0 (a),

(b), (c), and (d), or in the case of non-CAM method data, have been evaluated as comparable to CAM requirements. The validity and defensibility of the analytical data included in this report with respect to accuracy, precision, and completeness pursuant to MCP 310 CMR 40.1056(2)(k) have therefore been established.

12.5 Statement of Suitability

In summary, the data set relied upon in the Phase II to characterize the site conditions and perform a Risk Characterization is scientifically valid and defensible. It is of sufficient accuracy, precision, and completeness. In addition, the data set is representative of the spatial and temporal distribution of sampling points.

13. Phase III Remedial Action Plan

13.1 Summary

The process for completing a Phase III RAP is stipulated in the MCP and consists of identifying appropriate site-specific remedial objectives, identifying and screening potential remediation technologies, and completing a detailed evaluation of remedial alternatives for the Site. GEI assembled five Remedial Action Alternatives (RAAs) for detailed evaluation.

The RAAs considered in the detailed evaluation were:

- RAA1 – Site-wide EPEMs and Monitored Natural Attenuation (MNA)
- RAA2 – SVE at the Property, Site-wide EPEMs, and MNA
- RAA3 – Dual-Phase Extraction (DPE) at and Immediately East of the Property, MNA, and Downgradient EPEMs
- RAA4 – Chemical-Oxidation (Chem-Ox) at and Immediately East of the Property, MNA, and Downgradient EPEMs
- RAA5 – Hydraulic Control, MNA, and Site-wide EPEMs

GEI selected RAA2 (SVE at the Property, Site-wide EPEMs and MNA) based on a detailed evaluation of effectiveness, reliability, implementation difficulties, costs, risks associated with implementation of the technology, potential benefits, timeliness, and aesthetics.

All of the RAAs rely on EPEMs to achieve NSR by mitigating the vapor intrusion pathway into air inside buildings. Each of the RAAs has the potential to achieve a Permanent Solution within a comparable amount of time. The installation of EPEMs to mitigate the vapor intrusion pathway achieves NSR, and MNA will ultimately achieve a Permanent Solution, after many years, at the Site. In addition, the operation of the SVE system removes contaminant mass at the Property. Once EPEMs are installed in all buildings as proposed, the Site will operate in ROS.

Although RAA1 received a more favorable ranking than RAA2, RAA2 is preferable because operation of the SVE system will reduce the overall mass of contaminants at the Site. RAA2 is also preferable to RAA3, RAA4, and RAA5. RAA3 and RAA4 are unlikely to effectively meet the ultimate remedial goal of removing sufficient mass to result in significant concentration reductions in the downgradient plume in an appreciably different timeframe than the remaining RAAs. In addition, given the recalcitrant nature of residual DNAPL, the low permeability of soil at the Site, the presence of numerous subsurface structures and

utilities, and the significant number of properties on which the technology would need to be deployed, it is highly unlikely that these technologies could be effectively implemented. Similar to RAA3 and RAA4, RAA5 is technically complex, requires active operation and maintenance, and would require regular access to, and disruption of, multiple residential properties; all without achieving any substantial mass reduction.

13.2 Regulatory Requirements

The MCP requires that a Phase III RAP be completed for a site where a Phase II CSA has been completed and a Class A or B RAO has not yet been achieved (310 CMR 40.0852). The RAP identifies, evaluates, and recommends RAAs that are reasonably likely to achieve a Permanent or Temporary solution (i.e., NSR) considering the OHM present, media contaminated, and site characteristics. RAAs are assessed in two stages in accordance with 310 CMR 40.0855. The first stage is the identification of remedial technologies that can be combined to form RAAs, followed by an initial screening of each remedial technology based solely on feasibility. The second stage is the development of RAAs by combining remedial technologies that pass the initial screening, followed by an evaluation of each RAA based on eight criteria presented in 310 CMR 40.0858. In accordance with the MCP, the resulting recommended RAA must be a Permanent Solution unless a Permanent Solution is not feasible or a Temporary Solution is more cost-effective and timely.

13.2.1 Feasibilty

Feasibility evaluations are required at several specific points in the MCP, including when: selecting remedial alternatives; assessing measures to achieve background; and eliminating, mitigating or preventing a CEP.

In the MCP, feasible does not mean "possible." There is a clear articulation of the definition in DEP's July 14, 2004, policy, "Conducting Feasibility Evaluations under the MCP":

> Considerable confusion has historically existed over the meaning of "feasibility" under c.21 E and the MCP. In the context of the law and regulations, "feasible" is not synonymous with "possible." Feasibility is also not solely a function of cost. While feasibility has a number of regulatory components, as discussed in later sections of this policy, most decisions come down to one key determinant: do the benefits of achieving a remedial endpoint outweigh the costs?

The MCP (310 CMR 40.0860) establishes five criteria for evaluating feasibility:

1. Technological feasibility, which considers whether an existing technology can remediate OHM to the extent necessary to attain a level of NSR or background, is reliable, and complies with applicable regulatory requirements;
2. Cost-benefit, which considers whether the incremental cost of conducting the remedial action alternative is substantial and disproportionate to the incremental benefit of risk reduction, environmental restoration, and monetary and non-pecuniary values;
3. Availability of individuals with the expertise needed to effectively implement the alternative;
4. Availability of off-site land disposal alternatives that are in full compliance with all applicable federal and state regulatory requirements; and
5. Access by the party conducting the response action to the source of OHM.

13.2.2 ***Initial Screening Evaluation (ISE)***

The objective of ISE is to identify feasible remedial technologies (including innovative technologies) that would likely achieve the Remedial Action Objectives, with consideration given to the site-specific characteristics presented which may influence the feasibility of implementing remedial technologies. For purposes of the ISE, remedial technologies are reasonably likely to be considered feasible if:

- The technologies to be employed are reasonably likely to achieve a Permanent or Temporary Solution, and
- Individuals with the expertise needed to effectively implement available solutions would be available.

The technologies that pass the screening step are then compiled into RAAs. Each RAA is conceptually designed based on site-specific features and a detailed cost estimate is prepared. A detailed evaluation of the RAAs is then performed.

13.2.3 ***Detailed Evalution of RAAs***

The detailed evaluation of the RAAs provides the basis for selection of the recommended RAA. The eight criteria used for detailed evaluation as specified in 310 CMR 40.0858 are effectiveness, short-term and long-term reliability, difficulty in implementing, costs, risks, benefits, timeliness, and effect on non-pecuniary interests.

13.2.3.1 Effectiveness

The effectiveness criterion considers the likelihood of the remedial alternative: achieving a Permanent or Temporary Solution; reusing, recycling, destroying, detoxifying, or treating

OHM at the disposal site; and reducing levels of untreated OHM at the Site to concentrations that achieve or approach background.

13.2.3.2 Short-term and Long-term Reliablity

The short-term and long-term reliability criterion considers the degree of certainty that the alternative will be successful, and the effectiveness of any measures required to manage residues or remaining wastes, or to control emissions or discharges to the environment.

13.2.3.3 Difficulty in Implementing

The difficulty in implementing criterion considers technical complexity of the alternative; where applicable, the integration of the alternative with existing facility operations and other current or potential remedial actions; any necessary monitoring, operations, maintenance or site access requirements or limitations; the availability of necessary services, materials, equipment, or specialists; the availability, capacity and location of necessary off-site treatment, storage and disposal facilities; and whether the alternative meets regulatory requirements for any likely approvals, permits or licenses required by the DEP, or other state, federal or local agencies.

13.2.3.4 Costs

The costs criterion considers design, construction, equipment, site preparation, labor, permits, disposal, operation, maintenance, and monitoring; environmental restoration and potential damages to natural resources; and relative consumption of energy resources.

13.2.3.5 Risks

The risks criterion considers the short-term on-site and off-site risks posed during implementation of the alternative associated with any excavation, transport, disposal, containment, construction, operation or maintenance activities, or discharges to the environment from remedial systems; on-site and off-site risks posed over the period required for the alternative to attain applicable remedial standards, including risks associated with ongoing transport, disposal, containment, operation or maintenance activities, or discharges from remedial systems; and the potential risk of harm to health, safety, public welfare or the environment posed to human or environmental receptors by any OHM remaining at the disposal site after the completion of the remedial action.

13.2.3.6 Benefits

The benefits criterion considers restoring natural resources; providing for the productive reuse of the site; the avoided costs of relocating people, businesses, or providing alternative water supplies; and the avoided lost value of the site.

13.2.3.7 Timeliness

The timeliness criterion considers the timeframe required to eliminate any uncontrolled sources of OHM and to achieve of a level of NSR.

13.2.3.8 Effect upon Non-Pecuniary Interests

The effect of an alternative upon non-pecuniary interests criterion considers aesthetic values.

13.2.4 Reponse Action Performance Standards

The RAPS (310 CMR 40.0191(3)(b)) of the MCP require that consideration be given to: remedial actions that reduce, to the extent feasible, the overall contaminant mass; and, when a Permanent Solution is selected, remedial actions that will reduce, to the extent feasible, the levels of contamination to achieve or approach background. These objectives were considered in the detailed evaluation of alternatives.

13.2.5 Performance Standards

The performance standards in the MCP require that:

- The remedy is reasonably likely to result in a condition of NSR;
- The remedy is either a Permanent Solution or Temporary Solution;
- For a Permanent Solution, any source which is resulting or is likely to result in an increase in concentrations of OHM in an environmental medium either by direct discharge or by intermedia transfer (310 CMR 40.1003[5]) must be eliminated or controlled;
- For a Temporary Solution, any source which is resulting or is likely to result in an increase in concentrations of OHM in an environmental medium either by direct discharge or by intermedia transfer must be eliminated, controlled, or mitigated, to the extent feasible; and
- For a Permanent Solution, the feasibility to achieve or approach background must be evaluated.

13.2.6 Source

Regardless of whether the goal is to achieve a Permanent or Temporary Solution, the source of OHM which *is resulting or is likely to result in an increase in concentrations* of OHM in an environmental medium either by direct discharge or by intermedia transfer (310 CMR 40.1003[5]) must be eliminated or controlled (in the case of a Temporary Solution, it must be eliminated, controlled or mitigated to the extent feasible). Several examples of sources that

are specifically identified in the MCP include tanks, dry wells, contaminated fill, soil, other wastes, and NAPL.

By contrast, if a source is not resulting in, or is not likely to result in, an increase in concentrations of OHM in an environmental medium either by direct discharge or by intermedia transfer, the source need not be eliminated, controlled or mitigated. This may be the case at a site with a groundwater plume at steady state.

Short-term increases in concentrations caused by seasonal variability do not constitute an increase in OHM concentrations if the overall trend in concentrations demonstrates a steady state condition. Furthermore, the mere existence of a vapor intrusion pathway does not represent an *increase* in OHM concentrations by intermedia transfer.

According to DEP Q&A Volume 4, Number 1 (May 1997), a Permanent Solution can be achieved with NAPL present if it is demonstrated that the NAPL UCL specified in 310 CMR 40.0996(4) has not been exceeded and the NAPL does not represent a continuing source (310 CMR 40.1003(5)(a)(3)).

The analysis of site-specific data conducted by Kueper (2008b) showed that contaminant concentrations in groundwater at the Property and in the downgradient plume are at steady state. The analysis of likely DNAPL conditions at the Site (Kueper, 2008a) illustrated that DNAPL is present in the soil matrix, is not mobile, and is at steady state based on the distribution of contaminant concentrations in groundwater. This conclusion is further supported by the absence of measurable DNAPL in any monitoring well at the Site.

There is no source at the Site (including residual DNAPL) that is resulting in an increase in concentrations of contaminants in an environmental medium. In addition, there is no NAPL UCL condition. Therefore, remedial action solely to eliminate or control a source is not required.

13.3 Risk-Based Remedial Objectives

A condition of NSR is based on calculations of risk for present and potential future uses of the Site taking into account Site characteristics including: the extent of contamination; fate and transport of contaminants; potential exposure pathways; EPCs; and receptors of concern. Consistent with the requirements of the MCP, the risks to human health and the environment under current and future Site use scenarios were evaluated and a Method 3 Human Health Risk Characterization (Risk Characterization) and a Stage I Environmental Screening (Environmental Screening) were completed.

The risk characterization assumed:

- EPEMs would continue to be operated and/or maintained at residences where they had been installed to mitigate a CEP.
- EPEMS would be installed at residences where chlorinated VOCs were measured in indoor air in occupied living spaces above laboratory RLs to mitigate the CEP.
- The SSDS would continue to operate at the Capuano Center to mitigate the CEP.
- The SSDS would continue to operate at the Property, achieving a condition of NSR.

Therefore, based on the results of the Method 3 Risk Characterization, the following Remedial Objectives were identified:

Remedial Objective	**Location**	**Remedial Objective Description**	**Exposure Media**	**Primary COPC s**
1	Residences	Mitigate potential inhalation exposure to the extent feasible.	Indoor Air	Chlorinated VOCs (PCE, TCE, TCA)
2	Capuano Early Childhood Center	Mitigate potential inhalation exposure to the extent feasible.	Indoor Air	Chlorinated VOCs
3	Commercial buildings	Mitigate potential inhalation exposure to reach NSR.	Indoor Air	Chlorinated VOCs

The primary COPCs shown above are the targets of the remedial actions. The effect of reducing exposure to secondary COPCs (consisting of other compounds detected above background that may contribute to cumulative risk) was considered in the detailed evaluation.

In order to meet the Remedial Objectives for each of the locations, the vapor intrusion pathway must be controlled or mitigated and/or the concentration of chlorinated VOCs in groundwater must be reduced to a level such that it does not pose a potential for vapor intrusion.

13.4 Site-Specific Characteristics

Site-Specific characteristics that affected the selection of potential remedial technologies included:

- UniFirst does not own any of the properties that comprise the Site. Implementing remedial measures requires approval, cooperation, and coordination from numerous unrelated private and public entities.

- The privately owned properties at the Site are currently used for commercial and residential purposes. Public properties include a primary school, a playground, community gardens, and public streets.
- Numerous subsurface utilities will impede installation or operation of remedial systems.
- An active railroad abuts a significant portion of the Property.
- There is a downward gradient from overburden into bedrock indicating that bedrock groundwater is likely affected by dissolved phase VOCs and that residual DNAPL may be present in bedrock fractures.
- For a Permanent Solution, multiple AULs will be required to limit uses of properties within the Site boundary and to maintain passive and active remedial systems.

13.5 Initial Screening Evaluation

GEI identified those technologies that had the greatest potential to achieve the Remedial Objectives by controlling or mitigating the vapor intrusion pathway or reducing the concentration of chlorinated VOCs in groundwater to a level that would not pose the potential for vapor intrusion. The objective to reduce, to the extent feasible, the overall contaminant mass also was considered.

Both in situ technologies (technologies that treat or contain contaminants in place) and ex situ technologies (technologies applied after removal from the ground) were included. Technologies were selected from professional knowledge and experience, and a literature search of federal government documents and databases including the Remediation Technologies Screening Matrix and Reference Guide and the Federal Remediation Technologies Roundtable (FRTR) website.

The technologies listed in Table 13-1 (in situ technologies) and Table 13-2 (ex situ technologies) were screened for their implementability and potential effectiveness in meeting the Site remedial objectives. The ISE results for each technology identified are presented in Tables 13-3 and 13-4. Tables 13-3 and 13-4 contain summaries of the performance characteristics and relative costs of the alternatives, and the rationale for retention or elimination of identified technologies.

The in situ technologies retained for detailed evaluation were:

- EPEMS
    - Vapor Barrier
    - SSDS
    - Sub-slab Ventilation System (SSVS)

- SVE (with ex situ treatment)
- DPE (with ex situ treatment)
- Chem-Ox
- Hydraulic Control (with ex situ treatment)
- MNA

Of the ex situ technologies, Institutional Controls was retained for detailed evaluation. No other ex situ technologies were retained, except as a subordinant component for SVE, DPE, or Hydraulic Control. Excavation of soil with residual DNAPL was eliminated. Excavation would require that all soil with residual DNAPL be removed, including soil at the Property, soil beneath Tufts Street, soil beneath a portion of the neighborhood east of Tufts Street, and soil beneath a portion of the railroad right-of-way west of the Property. This work would require the demolition of numerous structures, and would result in tremendous disruption to the residential neighborhood and interruption of an important transportation corridor. In addition, the excavation alternative would not result in mitigation of the indoor air intrusion pathway in the downgradient plume for more than approximately 100 years, and therefore would not justify the effort or disruption. Several ex situ treatment options (incineration, biological treatments, soil washing, and vitrification) were eliminated from further consideration due to the limited effectiveness and reliability of the technologies or to their disproportionately high costs.

Descriptions of the technologies retained for detailed evaluation are presented in the following section.

13.6 Description of Remedial Action Technologies Retained for Detailed Evaluation

13.6.1 Exposure Pathway Elimination Measures

EPEMs may include one or more technologies designed to mitigate vapor intrusion and inhalation risk inside a building. Technologies that may be included in EPEMs include:

- Vapor Barrier – A vapor barrier mitigates the indoor air pathway. An impermeable membrane may be installed beneath a new slab, or a membrane or coating may be applied to an existing slab that is in good condition mitigating vapor intrusion to indoor air.
- SSDS – An SSDS actively mitigates the indoor air pathway by creating a vacuum beneath the building, drawing subsurface vapors into a collection system, and exhausting the vapors to the atmosphere. A network of sub-slab extraction points connected to a blower extracts potentially contaminated soil vapor. Off-gas treatment, such as carbon adsorption, may be required. This technology is suitable

for existing structures where installation of a vapor barrier beneath the floor slab is infeasible. The effectiveness of sub-slab depressurization for an existing building is dependent on the sub-slab soil conditions (e.g. soil permeability and depth to groundwater table). For new structures, a gas-collection layer may be installed below the slab to improve system efficiency.

- SSVS – An SSVS is similar in construction to an SSDS, but it does not require an active blower to create a vacuum below the slab. The SSVS uses passive components to equalize the air pressure between the atmosphere and sub-slab environment and to vent sub-slab vapors to the atmosphere.

A typical active residential EPEM would be an SSDS. A typical passive residential EPEM would consist of a vapor barrier system and an SSVS. If the existing basement slab is in good condition, a perimeter vapor trench would be installed and an epoxy coating applied to the floor. If the basement slab is in poor condition, or if a slab is not present, then a new slab would be installed over a vapor barrier consisting of a geocomposite vapor transmission layer and a high density polyethylene liner (HDPE). The vapor trenches or vapor transmission layer would be vented to the atmosphere with piping that extends above the roofline and includes a downdraft prevention cap. If a passive EPEM does not meet the performance standards it can be retrofitted with a blower and converted to an active system.

13.6.2 Soil Vapor Extraction

SVE is an in situ technology typically used for soil remediation. A vacuum is applied to the unsaturated subsurface soil, causing soil vapor to flow towards the extraction points, and thereby removing volatile contaminants from the soil. SVE can also be used to control the migration of contaminated soil vapor resulting from soil or groundwater contamination. The soil vapor collected by an SVE system may require ex situ treatment to remove contaminants prior to discharge to the atmosphere. SVE is most effective in high permeability soils and its effectiveness is limited in areas with a high groundwater table.

13.6.3 Dual-Phase Extraction

DPE, also known as multi-phase extraction or vacuum-enhanced extraction, is an in situ technology that uses a high-vacuum system to remove a mixture of contaminated groundwater (or NAPL) and soil vapor from the subsurface. Each extraction well includes a section screened in the zone of contaminated soil (or soil vapor) and groundwater. A vacuum tube installed in the well at the water level surface extracts a mixture of groundwater and soil vapor from the well, thereby removing sub-surface contaminants from above and below the water table. As the water table around the well is lowered by the extraction, contaminants in the newly exposed soil are accessible to vapor phase extraction. Low-permeability soils reduce the radius of influence of the extraction wells and limit the effectiveness of DPE

systems. Prior to implementation, a field study would be required to determine critical design parameters (e.g. radius of influence, number of extraction wells, vacuum required, air and water extraction rates).

13.6.4 **Chemical Oxidation**

Chem-Ox uses chemical solutions to reduce chlorinated VOCs to compounds which may be more stable, less mobile, and/or inert. The chemical oxidants most commonly used for environmental applications include hydrogen peroxide, ozone, persulfate, and permanganate. Delivering the oxidant to the areas with COPCs without remobilizing them is one of the key challenges. This alternative would involve the installation of numerous injection wells and continuous or periodic injections of oxidant. Prior to implementation, a bench-scale and field study would be required to develop the proper oxidant solution and determine system design parameters such as volume and frequency of injections and number of injection wells. It is also well recognized that Chem-Ox generally is not capable of achieving complete mass removal, particularly at sites such as the subject Site, where subsurface structures, preferential pathways, and access limitations are issues.

13.6.5 **Groundwater Extraction (Hydraulic Control)**

Groundwater extraction utilizes extraction wells screened in the zone of contamination to establish zones of hydraulic control. This technology is typically used to create a hydraulic barrier that prevents further contribution from the source of contamination to a downgradient plume. An in situ groundwater extraction system typically includes an ex situ treatment system to treat the groundwater prior to discharge. Key challenges for this technology are installing and pumping from enough locations to induce capture and locating pumping and treatment equipment to treat the groundwater for permitted discharge.

13.6.6 **Monitored Natural Attenuation**

Natural attenuation relies on natural subsurface processes such as dilution, dispersion, adsorption, chemical degradation, and biodegradation to reduce contaminant concentrations in groundwater. MNA is the technique of monitoring selected field parameters and collecting subsurface data to evaluate the effectiveness of ongoing natural attenuation processes. For example, DO, ORP, pH, and temperature can be monitored to confirm biodegradation of VOCs is occurring at the Site. MNA may be effectively utilized in combination with other remedial actions.

13.6.7 **Institutional Controls**

Institutional controls are restrictions imposed on access to property, or on the uses of a property, including natural resources and structures. Legal instruments, such as an AUL,

impose such restrictions. Institutional controls may be used for environmental or health protection concerns, for example, prohibiting residential use of some properties, specifying health and safety requirements during excavation and soil management, or requiring the maintenance of a vapor barrier or sub-slab ventilation system. The implementation of institutional controls would allow affected media to remain in place; however, the exposure pathways to human or environmental receptors would be restricted. This alternative would create no additional risks to the community, workers, or the environment. Institutional controls are cost-effective, easily implemented, and may be used effectively in conjunction with other remedial actions.

13.7 Development of RAAs

The remedial action technologies retained by the ISE for detailed evaluation were combined into five RAAs to achieve the Remedial Objectives and address site-specific characteristics:

- RAA1 – Site-wide EPEMs and MNA
- RAA2 – SVE at the Property, Site-wide EPEMs, and MNA
- RAA3 – DPE at and Immediately East of the Property, MNA, and Downgradient EPEMs
- RAA4 – Chem-Ox at and Immediately East of the Property, MNA, and Downgradient EPEMs
- RAA5 – Hydraulic Control, MNA, and Site-wide EPEMs

A detailed description of each RAA is presented below.

13.7.1 Common RAA Components – EPEMs with AULs

A common component of all the RAAs is the installation of EPEMs where chlorinated VOCs have been detected in the occupied space of a residence or school (a CEP) or concentrations of chlorinated VOCs measured in occupied commercial buildings exceed those constituting a condition of NSR. To achieve a permanent solution, AULs would be required for any property with an EPEM, enforceable for as long as an EPEM is required to mitigate the CEP and/or maintain a condition of NSR.

Based on these assumptions, GEI included the costs for installation and monitoring of EPEMs in each of the alternatives evaluated.

13.7.2 Detailed Evaluation Criteria

A comparative evaluation of the five RAAs was performed using the following detailed evaluation criteria:

- Effectiveness
- Reliability
- Implementation Difficulties
- Costs
- Risk
- Benefits
- Timeliness
- Non-Pecuniary Interests

13.8 Remedial Action Alternatives Evaluations

13.8.1 RAA1 – Site-wide EPEMs and MNA

13.8.1.1 EPEMs and AULs

RAA1 consists of EPEMs in residences and commercial buildings, as appropriate, that are located downgradient of the Property; continued operation of the existing SSDSs at the Property and the Capuano Center; and MNA (Fig. 13-1).

Currently, the SSDS at the Property consists of 22 sub-slab extraction points inside the building, a 15 HP blower installed outside the building, and off-gas treatment via two 2,000 lbs activated carbon adsorbers in series. As part of the SSDS installation, the building slab was sealed with a two-part industrial floor coating to minimize vapor transmission through the slab. The current flow rate of the SSDS is approximately 275 cfm.

The Capuano Center SSDS consists of 18 sub-slab extraction points, which were installed through the southern foundation wall of the instruction wing and connected to a 1.5 HP blower. Based on the current contaminant concentrations and a flow rate of approximately 100 cfm, off-gas treatment is not required for the Capuano Center SSDS.

To date, EPEMs have been installed at eight residential and commercial buildings as part of IRA activities conducted in 2007 and 2008. An Institutional Control (an AUL) may be recorded on the deeds for properties with an EPEM. The terms of the AULs would ensure that the EPEMs at the designated properties remain undisturbed and in good working order.

13.8.1.2 Monitored Natural Attenuation

An MNA program would be conducted to evaluate the attenuation processes in the downgradient plume and estimate the time required to achieve remedial objectives with respect to the downgradient plume. GEI assumed that approximately 20 groundwater

monitoring wells would be sampled on an annual basis for analysis of chlorinated VOCs and measurements of typical indicator parameters (e.g. DO, pH, ORP, temperature).

13.8.1.3 Regulatory Endpoint

The MCP does not specify a time-frame for reaching a Permanent Solution; therefore RAA1 has the potential to achieve a Permanent Solution. The installation of EPEMs to mitigate the vapor intrusion pathway achieves NSR, and MNA will ultimately achieve a permanent solution at the Site. Once EPEMs are installed in all buildings as appropriate, the Site will operate in ROS.

13.8.1.4 Effectiveness

- The effectiveness of EPEMs has been illustrated by their successful implementation as IRAs at the Property, Capuano Center, and residences.
- RAA1 will ultimately achieve a Permanent Solution (Class A-3 RAO) and will achieve ROS once all EPEMs are installed.
- RAA1 will not significantly reduce the contaminant mass at the Site, nor achieve or approach background conditions.

13.8.1.5 Reliability

- RAA1 has been shown to be reliable for eliminating or mitigating inhalation risk at the Site.
- An AUL on each property deed would ensure the long-term reliability of the EPEMs.

13.8.1.6 Implementation Difficulties

- The SSDSs at the Property and the Capuano Center, and residential EPEMS have already been implemented as IRAs with moderate difficulty. Installation of additional residential EPEMs is ongoing. The implementation difficulties are moderate and will require negotiating terms of access with numerous individual property owners.
- Some building owners have refused to permit installation of an EPEM.
- This alternative will require periodic inspections to confirm that the passive EPEMs remain effective in the future. The active SSDSs will require an inspection and maintenance program and semiannual reporting to the DEP.
- The SSDS at the Property will continue to require off-gas treatment by carbon adsorption prior to discharge and periodic off-site hazardous waste disposal of the

spent granulated activated carbon (GAC), both of which have been implemented with minimal difficulty.

13.8.1.7 Cost

The estimated cost for this alternative in 2008 dollars is $8,230,000 (based on 30-year duration). The cost estimate is in Appendix O.

13.8.1.8 Risks

RAA1 poses minimal risks to human health or ecological receptors during the implementation period. The SSDS at the Property creates moderate risks associated with the off-gas treatment prior to discharge to the atmosphere and generates hazardous waste for off-site disposal. Long-term inhalation risks to residents or building occupants are adequately managed through EPEMs and AUL criteria, where implemented.

13.8.1.9 Benefits

RAA1 allows continued residential and commercial use of the Site, consistent with current uses.

13.8.1.10 Timeliness

Based on the current rate of residential EPEM installation, GEI expects that installation of the systems will be completed in 2 to 3 years. RAA1 will achieve a condition of NSR in a similar time period as all RAAs considered since they all rely on the construction of EPEMs. However, RAA1 is considered the timeliest of the RAAs, because it is not affected by the time to operate other remedial systems that are included in the other RAAs.

13.8.1.11 Effect on Non-Pecuniary Interests

RAA1 will have a relatively minor effect on overall aesthetic values at the Site, although installation of EPEMs may result in functional or aesthetic improvements to some individual residences and commercial buildings.

13.8.2 RAA2 – SVE at the Property, Site-wide EPEMs, and MNA

RAA2 is similar to RAA1, but includes the continued operation of the existing SVE system at the Property (Fig. 13-2).

13.8.2.1 Soil Vapor Extraction

The SVE system is currently operated as an IRA and removes contaminants from the vadose zone. The SVE system consists of two extraction zones, with a total of seven extraction

points, in the northern and southern parking areas at the Property. It uses the same mechanical blower and off-gas treatment system as the SSDS. The flow rate contributed by the SVE system is approximately 80 cfm. Under RAA2, the SSDSs for the Property and Capuano Center would continue to operate, and EPEMs would be installed in other buildings located downgradient of the Property.

13.8.2.2 Monitored Natural Attenuation

An MNA program would be conducted to evaluate the attenuation processes in the downgradient plume and estimate the time required to achieve remedial objectives with respect to the downgradient plume. Approximately 20 groundwater monitoring wells would be sampled on an annual basis for analysis of chlorinated VOCs and measurements of typical indicator parameters (e.g. DO, pH, ORP, temperature).

13.8.2.3 Regulatory Endpoint

The MCP does not specify a time-frame for reaching a Permanent Solution; therefore RAA2 has the potential to achieve a Permanent Solution. The installation of EPEMs to mitigate the vapor intrusion pathway achieves NSR, and MNA will ultimately achieve a permanent solution at the Site. Once EPEMs are installed in all buildings as required, the Site will operate in ROS.

13.8.2.4 Effectiveness

- The effectiveness of EPEMs has been illustrated by their successful implementation as IRAs at the Property, Capuano Center, and residences.
- RAA2 will ultimately achieve a Permanent Solution (Class A-3 RAO) and will achieve ROS once all EPEMs are installed.
- The SVE system has been shown to be very effective in removing contaminant mass from the vadose zone at the Property, but RAA2 will not achieve or approach background conditions for the Site.

13.8.2.5 Reliability

- EPEMs have been shown to be reliable for eliminating or mitigating inhalation risk at the Site, and the SVE system is considered reliable for removing contaminants from the vadose zone.
- The off-gas treatment system and monitoring program have been shown to be reliable for preventing the discharge of VOCs to the atmosphere.
- An AUL on each property deed would ensure the long-term reliability of the EPEMs.

13.8.2.6 Implementation Difficulties

- The SVE system at the Property, the SSDSs for the Property building and the Capuano Center, and seven residential EPEMs required by RAA2 have already been constructed with moderate difficulty. Installation of additional residential EPEMs is ongoing. Ongoing implementation difficulties are moderate and will require negotiating access terms with numerous individual property owners.
- Some building owners have refused to permit the installation of an EPEM.
- This alternative will require periodic inspections to confirm that the passive EPEMs remain effective in the future. The active SSDSs and SVE system will require an inspection and maintenance program and semiannual reporting to the DEP.
- The SVE system and SSDS at the Property will continue to require off-gas treatment by carbon adsorption prior to discharge and periodic off-site hazardous waste disposal of the spent GAC, both of which have been implemented with minimal difficulty.

13.8.2.7 Cost

The estimated cost for this alternative in 2008 dollars is $8,530,000 (based on 30-year duration). The cost estimate is in Appendix O.

13.8.2.8 Risks

RAA2 poses minimal risks to human health or ecological receptors during the implementation period. The SVE system will require off-gas treatment prior to discharge to the atmosphere which will generate hazardous waste for off-site disposal, but the short term risks are minimal and have been managed effectively. Long-term inhalation risks to residents or building occupants will be adequately managed through the permanent EPEMs and AULs criteria, where implemented.

13.8.2.9 Benefits

RAA2 allows continued residential and commercial use of the Site, consistent with current uses.

13.8.2.10 Timeliness

Based on the current rate of residential EPEM installation, GEI expects that installation of the remaining systems will be completed in 2 to 3 years. RAA2 will achieve a condition of NSR in a similar time period as all RAAs considered since they all rely on the construction of EPEMs. However, RAA2 is considered timelier than RAA3, RAA4, and RAA5 because it requires less time than those alternatives for the operation of remedial systems.

13.8.2.11 Effect on Non-Pecuniary Interests

RAA2 will have a relatively minor effect on overall aesthetic values at the Site, although installation of EPEMs may result in functional or aesthetic improvements to some individual residences and commercial buildings.

13.8.3 RAA3 – DPE at and Immediately East of the Property, MNA, and Downgradient EPEMs

RAA3 consists of:

- Remediation at and immediately east of the Property using DPE wells;
- EPEMs for buildings downgradient of the Property; and
- MNA of the downgradient plume.

The primary difference between RAA3 and RAA1/RAA2 is its potential ability to remove contaminant mass from both the vadose zone and saturated soil above bedrock at the Property as a means to accelerate attenuation of the downgradient plume. In addition, if DPE is successful, the concentration of chlorinated VOC at and immediately east of the Property may be reduced to a level that would mitigate the indoor air inhalation pathway and the EPEMs in that area would no longer be necessary. The EPEMs would remain in place downgradient of the DPE as natural attenuation progresses.

13.8.3.1 DPE System

Approximately 105 DPE wells would be installed on a 30-foot grid pattern throughout the Property and the area immediately east of the Property (Fig. 13-3). Directional drilling may be required to install wells below the Property building. Each DPE well would be about 20 feet deep and screened above and below the water table (e.g. 5 to 20 feet deep). A vacuum extraction tube would be installed in each well, with the tubing inlet located at the water level surface. The tubing would extract a mixture of groundwater and soil vapor from the well and be connected to a subsurface pipe network installed below Tufts Street, with secondary containment. The vapor from the DPE wells would be drawn through the collection pipe network by vacuum, and the water would flow via gravity to a central treatment building. Alternately, lift stations may be utilized to transfer the groundwater to the treatment building. GEI estimates the system of DPE wells would collect approximately 1,100 cfm of subsurface vapors and 15 gpm of groundwater. Although the reliability of this alternative is extremely low, for estimating purposes it was assumed that the system would have to operate for at least 10 years to remove sufficient contaminant mass to eliminate the need for EPEMs at and immediately east of the Property. A quarterly monitoring program of the soil vapor and groundwater in the source area would be conducted.

A central treatment building (approximately 2,000 sf) would be constructed. The groundwater would be treated using an air stripper to remove most chlorinated VOCs and then pass through two liquid-phase GAC adsorbers in series for polishing prior to discharge to a storm drain under a NPDES permit. GEI has assumed that dissolved iron removal would not be required to enable groundwater treatment for VOCs. The off-gas from the air stripper and the soil vapor from the DPE wells would be treated using catalytic oxidation equipment that destroys VOCs. Oxidation of the chlorinated VOCs would require a wet scrubber to remove hydrogen chloride from the air stream before discharge to the atmosphere. The wet scrubber would generate approximately 140 tons per year of brine slurry for off-site disposal.

13.8.3.2 Downgradient EPEMs and AULs

It is estimated that EPEMs would be required at the Capuano Center and the residences downgradient from the DPE area for more than approximately 100 years until the dissolved phase VOCs in the downgradient plume naturally attenuate to levels that would not result in unacceptable concentrations in indoor air, assuming that a pathway exists. For this alternative, EPEMs would not be necessary in buildings at or immediately east of the Property if the DPE process is successful; however, interim EPEMs would be necessary until completion of the DPE process.

13.8.3.3 Monitored Natural Attenuation

An MNA program would be conducted to evaluate the attenuation processes in the downgradient plume and to estimate the time required to achieve remedial objectives with respect to the downgradient plume. Approximately 20 groundwater monitoring wells would be sampled on an annual basis for analysis of chlorinated VOCs and measurements of typical indicator parameters (e.g. DO, pH, ORP, temperature).

13.8.3.4 Regulatory Endpoint

The MCP does not specify a time-frame for reaching a Permanent Solution; therefore RAA3 has the potential to achieve a Permanent Solution, but it is estimated that it would require more than 100 years. The installation of EPEMs to mitigate the vapor intrusion pathway achieves NSR, and MNA will ultimately achieve a permanent solution at the Site. Once the DPE is operational and EPEMs are installed, the Site will operate in ROS.

13.8.3.5 Effectiveness

- The effectiveness of EPEMs has been illustrated by their successful implementation as IRAs at the Property, Capuano Center, and residences.
- RAA3 will ultimately achieve a Permanent Solution (Class A-3 RAO) and will achieve ROS once the DPE is operating and all required EPEMs are installed.

- The DPE component of RAA3 may reduce contaminant mass above bedrock at and immediately east of the Property, but would not result in complete removal and would not achieve or approach background conditions at the Site.

13.8.3.6 Reliability

- RAA3 may remove a significant mass of chlorinated VOCs, but it is not considered reliable for removing VOCs in the saturated zone to an extent sufficient to make downgradient EPEMs unnecessary. The low permeability soil conditions, preferential migration pathways, and presence of multiple subsurface utilities at the Site will limit the area of influence of the DPE system. Access issues at multiple private properties will severely constrain where the wells and piping can be installed and reduce the reliability of the system to remove VOCs from the subsurface.
- The reliability of treatment systems for the liquid phase and gas phase material produced is expected to be good, but it is lower than RAA2 (SVE) because of the requirements to manage multiple, high concentration waste streams, and the increased complexity of the treatment system.

13.8.3.7 Implementation Difficulties

- The DPE system requires numerous extraction wells on multiple properties, an intrusive piping network for the collection of soil vapor and groundwater, and approximately 1,500 to 2,000 sf of space for a treatment building. Site constraints will prevent effective implementation.
- There is considerable technical complexity associated with the components of the DPE system, including locating an effective extraction well network, operation of the extraction and collection mechanisms, and treatment of extracted vapor and water. GEI assumed that iron treatment would not be required; however, the presence of dissolved iron in the groundwater would significantly increase the cost and difficulty of groundwater treatment.
- Compared to RAA1 and RAA2, this alternative will require a much more comprehensive inspection, monitoring, and maintenance program and monthly reporting for the treatment system. The air and groundwater treatment system would likely require a full-time operator.

13.8.3.8 Cost

The estimated cost for this alternative in 2008 dollars is $20,200,000 (based on 30-year duration). The cost estimate is in Appendix O.

13.8.3.9 Risks

- Installation of the DPE wells and piping network would generate significant quantities of potentially impacted soil to be managed during construction. The drilling and excavation activities associated with the DPE system installation could potentially cause damage to subsurface utilities and/or require relocation of utilities.
- RAA3 would generate continuous vapor and water waste streams on residential and commercial properties and pose a significant short-term risk during operation of the system.
- The wet scrubber required for the air treatment system would use, and generate, significant quantities of potentially hazardous compounds which pose a risk of accidental discharge to the atmosphere during operation.
- As with RAA1 and RAA2, long-term indoor air inhalation risks to residents or occupants would be adequately managed through EPEMs and AULs.

13.8.3.10 Benefits

- As with RAA1 and RAA2, this alternative allows continued residential and commercial use of the Site; however, it has likely additional short-term relocation costs for residents during installation, and longer-term disturbance to, or relocation of, commercial activities in order to construct a treatment system building.
- If DPE is successful, EPEMs may not be required at and immediately east of the Property.

13.8.3.11 Timeliness

GEI expects to install the remaining EPEMs over the next 2 to 3 years. Assuming access is obtained, the DPE system installation would also take 2 to 3 years. RAA3 will achieve a condition of NSR in a similar time period as all RAAs considered since they all rely on the construction of EPEMs. If it were effective, it is estimated that most contaminant mass at and immediately east of the Property would be removed in approximately 10 years, and potentially achieve conditions in the downgradient plume such that EPEMs would not be required in approximately 100 years.

13.8.3.12 Effect on Non-Pecuniary Interests

- The presence and maintenance of the numerous DPE wells and associated treatment plant will detract from the residential neighborhood atmosphere.
- Like RAA1 and RAA2, the installation of EPEMs may result in functional or aesthetic improvements to some individual residences and commercial properties.

13.8.4 RAA4 – Chem-Ox at and Immediately East of the Property, MNA, and Downgradient EPEMs

RAA4 is similar to RAA3, except that attempts at remediation at and immediately east of the Property would be by Chem-Ox, rather than DPE. Chem-Ox would be injected into the vadose zone and groundwater throughout the Property area and the area immediately east of the Property. In areas where it successfully made contact with in situ chlorinated VOCs, the oxidant would cause a reaction that would reduce chlorinated VOCs to compounds that are less mobile and/or inert.

As with RAA3, RAA4 has the potential value of reducing VOC mass in both the vadose zone and groundwater above bedrock, but it is unlikely to achieve complete removal of VOCs in the saturated zone above bedrock. If Chem-Ox were successful, the concentration of chlorinated VOCs at and immediately east of the Property may be reduced to a level that would mitigate the indoor air inhalation pathway and render the EPEMs in the area of the Chem-Ox application unnecessary. EPEMs would remain in place downgradient of the Chem-Ox area as natural attenuation progresses.

13.8.4.1 Chem-Ox System

Because of the low permeability soils at the Site, approximately 406 injection wells were assumed to be required on a 15-foot grid pattern to produce an injection network with overlapping influence throughout and immediately east of the Property (Fig. 13-4). Each injection well would be constructed of 2-inch schedule 40 PVC and be installed to a depth of about 20 feet. Persulfate would be injected over the course of two rounds using a mobile, trailer-mounted chemical dosing system. Persulfate was chosen as the oxidant because it possesses less harmful properties than other typical oxidants (e.g. hydrogen peroxide, potassium permanganate) and is more suitable for application in a residential neighborhood. A quarterly monitoring program of soil vapor and groundwater would be conducted in the application area.

13.8.4.2 Downgradient EPEMs and AULs

As with RAA3, it is estimated that EPEMs would be required at the Capuano Center and the residences downgradient from the Chem-Ox area for approximately 100 years until the dissolved phase VOCs in the downgradient plume naturally attenuate to levels that would not result in a significant vapor migration pathway to indoor air. For this alternative, EPEMs would not be necessary in buildings at or immediately east of the Property if the technology is successful; however, interim EPEMs would be necessary until completion of the Chem-Ox process.

13.8.4.3 Monitored Natural Attenuation

As with RAA3, an MNA program would be conducted to evaluate the attenuation processes in the downgradient plume and to estimate the time required to achieve remedial objectives with respect to the downgradient plume. Approximately 20 groundwater monitoring wells would be sampled on an annual basis for analysis of chlorinated VOCs and measurements of typical indicator parameters (e.g. DO, pH, ORP, temperature).

13.8.4.4 Regulatory Endpoint

The MCP does not specify a time-frame for reaching a Permanent Solution; therefore RAA4 has the potential to achieve a Permanent Solution, but it is estimated to take more than 100 years. The installation of EPEMs to mitigate the vapor intrusion pathway achieves NSR, and MNA will ultimately achieve a permanent solution at the Site. Once the Chem-Ox is initiated and EPEMs are installed in all buildings as appropriate, the Site will operate in ROS.

13.8.4.5 Effectiveness

- The effectiveness of EPEMs has been illustrated by their successful implementation as IRAs at the Property, Capuano Center, and residences.
- RAA4 will ultimately achieve a Permanent Solution (Class A-3 RAO) and will achieve ROS once the Chem-Ox is initiated and all required EPEMs are installed.
- The Chem-Ox component of RAA4 may reduce contaminant mass above bedrock at and immediately east of the Property, but would not achieve complete removal and would not achieve or approach background conditions at the Site.

13.8.4.6 Reliability

- Chem-Ox is likely to remove a significant mass of chlorinated VOCs but is highly unlikely to be successful at treating all source material in the unsaturated and saturated zones to an extent sufficient to make EPEMs unnecessary downgradient. The low permeability soil conditions, heterogeneities, and the presence of preferential pathways in the subsurface are likely to prevent the effective delivery of chemical oxidants to contaminated soil. The presence of high concentrations of natural organic material in the soil will consume large amounts of the oxidants, leaving less for the destruction of chlorinated VOCs. Access issues at multiple private properties may also affect where the injection wells can be installed and reduce the reliability of the system.
- The effectiveness of measures to manage the side-effects of the Chem-Ox process is uncertain. The process generates significant heat in the subsurface and could affect

subsurface utilities and conditions in basements. Subsurface utilities could behave as conduits for the migration of the chemical oxidants away from the intended treatment area and into structures, creating exposure and physical risks.

13.8.4.7 Implementation Difficulties

- Extensive access arrangements would be required to implement the Chem-Ox system because it requires hundreds of injection wells on multiple properties.
- The presence of multiple subsurface structures, basements, and utilities would prevent the effective delivery of oxidants to all subsurface soil requiring treatment. The injections would result in seepage of the chemicals injected into basements and utilities and would require numerous, technically complex controls to prevent potential contact with people.
- The lack of any active mechanical or treatment systems makes this alternative less technically complex than RAA3, with fewer monitoring and reporting obligations. However, complete treatment is likely to require multiple injection rounds and repeated access to private properties.

13.8.4.8 Cost

The estimated cost for this alternative in 2008 dollars is $12,300,000 (based on 30-year duration). The cost estimate is in Appendix O.

13.8.4.9 Risks

- Installation of the Chem-Ox injection wells would generate significant quantities of potentially impacted soil to be managed during construction. Drilling hundreds of injection wells would likely cause disturbance and potential damage to subsurface utilities.
- There is significant risk that the injection of chemical oxidants under pressure could result in the mobilization and redistribution of connected phase DNAPL, potentially resulting in the expansion or worsening of the dissolved-phase plume.
- The large quantities of oxidant necessary for injection would require extensive safe management practices. The heat produced by the reaction between the contaminants and the oxidant may require monitoring and limit the allowable oxidant injection rate. In addition, there could be adverse interactions between the chemical oxidant and some subsurface utilities.
- As with the other RAAs being considered, the long-term indoor air inhalation risks to residents or occupants would be managed adequately through EPEMs and AULs.

13.8.4.10 Benefits

- This alternative allows continued residential and commercial use of the Site; however, it has likely additional short term relocation costs for residents during well installation and injection of oxidants in the source area.
- Similar to RAA3, if Chem-Ox is successful, EPEMs may not be required at and immediately east of the Property.

13.8.4.11 Timeliness

GEI expects to install the remaining EPEMs over the next 2 to 3 years. Assuming access is obtained, Chem-Ox application would be completed over 2 to 3 years. RAA3 would achieve a condition of NSR in a similar time period as all RAAs considered since they all rely on the construction of EPEMs. If Chem-Ox is successful, it is estimated that much of the contaminant mass at and immediately east of the Property would be removed in approximately 1 to 2 years, and potentially achieve conditions in the downgradient plume such that EPEMs would not be required in approximately 100 years.

13.8.4.12 Effect on Non-Pecuniary Interests

- The installation and presence of the hundreds of Chem-Ox injection wells would detract from the aesthetics of the residential neighborhood.
- Like RAA1 and RAA2, the installation of EPEMs may result in functional or aesthetic improvements to some individual residences and commercial properties.

13.8.5 RAA5 – Hydraulic Control, MNA, and Site-wide EPEMs

RAA5 differs from RAA3 and RAA4, in that, rather than attempting to attack source material using multiple distributed extraction or injection points it would generate a zone of hydraulic capture around the source area. Because the system would only treat dissolved phase contaminants in the groundwater, it would not result in substantial source mitigation and removal.

13.8.5.1 Hydraulic Control

The hydraulic control component of RAA5 consists of approximately twenty, 6-inch diameter Schedule 40 PVC extraction wells installed east of the Property (Fig. 13-5). To create an overlapping zone of influence, a network of wells would be spaced about 40 feet apart and extract a total of approximately 15 gpm of groundwater. The groundwater would be extracted from each well using a submersible pump and delivered to a central treatment building via a subsurface piping network.

A central treatment building (approximately 1,500 sf) would be constructed on, or near, the source area. Like RAA3, it was assumed that groundwater would be treated using an air stripper to remove most chlorinated VOCs and then passed through two liquid-phase GAC adsorbers in series for polishing prior to discharge to a storm drain under a NPDES permit. It was also assumed that dissolved iron removal would not be required to enable groundwater treatment for chlorinated VOCs, and that the off-gas from the air stripper would require treatment using catalytic oxidation equipment for VOC destruction. Oxidation of the chlorinated VOCs would require a wet scrubber to remove hydrogen chloride from the air stream before discharge to the atmosphere. It is estimated that the wet scrubber would generate approximately 47 tons per year of brine slurry for off-site disposal.

13.8.5.2 Site-wide EPEMs and AULs

As with RAA3 and RAA4, EPEMs would be required at the Capuano Center and the residences downgradient of the hydraulic containment system for up to approximately 100 years until the dissolved phase VOCs in the downgradient plume naturally attenuate to levels that would not result in a significant vapor migration pathway to indoor air. For this alternative, EPEMs would also be required for buildings at and immediately east of the Property.

13.8.5.3 Monitored Natural Attenuation

As with RAA3 and RAA4, an MNA program would be conducted to evaluate the attenuation processes in the downgradient plume and estimate the time required to achieve remedial objectives with respect to the downgradient plume. Approximately 20 groundwater monitoring wells would be sampled on an annual basis for analysis of chlorinated VOCs and measurements of typical indicator parameters (e.g. DO, pH, ORP, temperature).

13.8.5.4 Regulatory Endpoint

The MCP does not specify a time-frame for reaching a Permanent Solution; therefore RAA5 has the potential to achieve a Permanent Solution, but it is estimated to take more than 100 years. The installation of EPEMs to mitigate the vapor intrusion pathway achieves NSR, and MNA will ultimately achieve a permanent solution at the Site. Once the hydraulic control system is operating and EPEMs are installed in all buildings as required, the Site will operate in ROS.

13.8.5.5 Effectiveness

- The effectiveness of EPEMs has been illustrated by their successful implementation as IRAs at the Property, Capuano Center, and residences.

- RAA5 will ultimately achieve a Permanent Solution (Class A-3 RAO) and will achieve ROS once the hydraulic control system is operating and all required EPEMs are installed.
- RAA5 would be capable of only relatively low VOC mass removal rates because it is dependent on the dissolution of residual DNAPL from soil pores into the aqueous phase, which is a slow process for PCE, TCE, and TCA. This alternative would not achieve or approach background conditions at the Site.

13.8.5.6 Reliability

- Groundwater extraction and treatment is an established technology for establishing hydraulic control for dissolved-phase contaminants in groundwater.
- The reliability of treatment systems for the liquid phase waste streams is expected to be moderate because of the requirements to manage the groundwater waste stream for a long period.
- The EPEMs will be effective in eliminating inhalation risk to current and future residents and occupants at the Site.

13.8.5.7 Implementation Difficulties

- There is significant technical complexity associated with the components of the hydraulic control system. Multiple wells and extensive subsurface piping with secondary containment would be required in a substantial portion of the residential neighborhood. Piping would have to cross over or beneath multiple subsurface utilities.
- Due to the low permeability of Site soil and the effects of subsurface structures and utilities, siting appropriate groundwater extraction wells to completely capture the overburden groundwater plume is expected to be very difficult.
- GEI has assumed that iron treatment would not be required; however, the presence of high concentrations of dissolved iron in the groundwater would significantly increase the cost and difficulty of groundwater treatment.
- The groundwater extraction system would require numerous extraction wells on multiple properties, an extensive subsurface piping network, and approximately 1,500 to 2,000 sf of space for a treatment building. Site constraints are likely to prevent effective implementation.
- Similar to RAA3, this alternative would require a comprehensive inspection, monitoring, and maintenance program and monthly reporting for the treatment system. The groundwater treatment system would likely require a part-time operator.

13.8.5.8 Cost

The estimated cost for this alternative in 2008 dollars is $14,800,000 (based on a 30-year duration). The cost estimate is in Appendix O.

13.8.5.9 Risks

- Installation of the groundwater extraction wells and piping network would generate significant quantities of potentially impacted soil to be managed during construction. The drilling and excavation activities associated with the hydraulic control system installation could potentially cause damage to subsurface utilities.
- RAA5 would generate a continuous stream of extracted water, piped through multiple residential and commercial properties, and require management for the foreseeable future.
- The wet scrubber required for the assumed off-gas treatment system would use, and generate, significant quantities of potentially hazardous compounds.
- As with the other RAAs considered, long term indoor air inhalation risks to residents or occupants would be adequately managed through EPEMs and AULs.

13.8.5.10 Benefits

- As with the other RAAs, this alternative allows continued residential and commercial use of the Site.
- Implementation of this alternative would not likely require the relocation of local residents, but would require the lease or purchase of land for the treatment system building, taking it out of commercial use for the foreseeable future.

13.8.5.11 Timeliness

GEI expects to install the remaining EPEMs over the next 2 to 3 years. Assuming access is obtained, the Hydraulic Control system could be installed in 2 to 3 years. RAA5 will achieve a condition of NSR in a similar time period as all RAAs considered since they all rely on the construction of EPEMs, but provides no improvement in long-term timeliness over RAA1 or RAA2.

13.8.5.12 Effect on Non-Pecuniary Interests

- The presence and maintenance of the numerous groundwater extraction wells and associated treatment plant may detract from the residential neighborhood atmosphere.
- Like the other RAAs, the installation of EPEMs may result in functional or aesthetic improvements to some individual residences.

13.9 Qualitative Scoring of RAAs

GEI ranked each of the RAAs for each criterion using a numeric scoring system, with a score of one being the best for that criterion, and a score of four being the least preferred. GEI then added the scores for each RAA to get a cumulative ranking based on all criteria. A summary of our scoring of the RAAs for each of the eight criteria, along with the overall qualitative scores for the RAAs, are presented in Table 13-5. The overall qualitative scores are listed below (lower score preferred):

Remedial Action Alternatives	**Score**
RAA1 - Site-wide EPEMs and MNA	33
RAA2 - SVE, Site-wide EPEMs and MNA	37
RAA3 - DPE at and Immediately East of the Property, MNA, and Downgradient EPEMs	57
RAA4 - Chem-Ox at and Immediately East of the Property, MNA, and Downgradient EPEMs	56
RAA5 - Hydraulic Control, MNA, and Site-wide EPEMs	58

A summary comparison for each of the eight criteria is presented below:

13.9.1 Effectiveness

RAA3 and RAA4 ranked most favorably for this criterion because both RAAs would likely result in the greatest contaminant mass reduction, although neither is likely to be effective in removing all contaminant mass from either soil beneath the water table or from contaminants in bedrock fractures. As a result, even though they may remove comparatively more contaminant mass than other alternatives, RAA3 and RAA4 are likely to be ineffective in achieving their ultimate remedial goal of removing sufficient contaminant mass to produce significant reductions in concentrations downgradient. RAA2 ranked third because it would also result in significant contaminant mass removal but is less effective at contaminant mass removal below the water table and relatively ineffective at removal of contaminant mass from bedrock. RAA5 ranked fourth because it will result in contaminant mass removal but at a relatively low rate and is also relatively ineffective at removal of contaminant mass from bedrock. RAA1 ranked last because it relies solely on pathway elimination and would result in the least amount of contaminant mass removal of the five alternatives.

13.9.2 Reliability

RAA1 and RAA2 were ranked as the most reliable because both have already been successfully applied at the Site as IRA activities. RAA5 was ranked third because it has been widely used at contaminated sites and is well-tested, although significant uncertainty exists relative to its ability to intercept all groundwater at the Site given the presence of numerous subsurface structures and utilities at the Site that affect local flow conditions. RAA3 and RAA4 were ranked fourth and fifth, respectively, because they are unlikely to be successful

given complex subsurface conditions at the Site, low permeability soil, and preferential flow pathways. The reliability is very low for systems and controls to manage wastes, deliver chemicals (in the case of RAA4), and prevent side-effects resulting from subsurface physical and chemical processes. RAA4 was ranked last largely due to the uncertainties associated with managing the injection of chemical oxidants in proximity to private residences.

13.9.3 Implementation Difficulties

RAA1 ranked first for this criterion because of its relative ease of implementation when compared to the other alternatives, primarily because it does not require extensive subsurface work. RAA2 ranked second because it required installation of additional subsurface components with higher technical complexity and requires active operation and maintenance and regular site access. RAA3, RAA4, and RAA5 ranked substantially lower because they would all have much greater technical complexity; require active operation and maintenance; and require regular access to, and disruption of, multiple residential properties owned by others. RAA3 ranked last of the group primarily because of the number of dual-phase extraction points required at residential properties and treatment requirements for multiple waste streams (vapor and water).

13.9.4 Cost

RAA1 and RAA2 ranked most favorably for this criterion with estimated costs of $7,950,000 and $8,280,000, respectively. RAA4 was ranked third with a cost of $11,900,000. RAA5 was ranked fourth ($13,900,000) and RAA3 was ranked last ($19,800,000). The costs of RAA3 and RAA4 may be significantly greater than estimated due to the direct and indirect costs associated with mobilizing throughout an urban area with narrow streets and multiple individual small properties, and the need to install dozens of extraction/injection points and subsurface piping.

13.9.5 Risks

RAA1 and RAA2 ranked first and second, respectively, for this criterion because they have been shown to have minimal short-term risks during implementation. RAA2 ranked slightly lower than RAA1 because of the higher risks associated with the management of contaminated vapor and spent carbon from the SVE system. However, both RAA1 and RAA2 had higher potential long-term risks than RAA3, RAA4, and RAA5 due to the higher mass of contaminants remaining after completion of the remedies. RAA3 had high short-term risks due to the need to manage multiple waste streams (vapor and water) at residential properties. RAA5 ranked low because of the risks associated with waste management and treatment over the indefinite period required for operation. RAA4 had the highest risks associated with operation and maintenance, potential discharges to the environment during the time required to achieve its remedial standards, and the potential for remobilizing

connected phase DNAPL and exacerbating contaminant conditions at the Site. The result was that RAA3 ranked third of the five alternatives and RAA4 and RAA5 tied for fourth.

13.9.6 Benefits

RAA3 and RAA4 ranked highest compared to the other alternatives for this criterion because, in the unlikely event they were successful, they could potentially eliminate the need for EPEMs or AULs on a portion of the Site. RAA1 and RAA2 tied for third in terms of net benefits because they allow for full productive site use consistent with current uses and avoid potential costs associated with relocating people and businesses during remedy implementation. Given the extensiveness of the subsurface installations of piping and equipment required for RAA3, RAA4, and RAA5, it is assumed that the use of the residences between Tufts Street and Morton Street and the business at the Property would be interrupted and there would be extensive closing of streets, relocation of traffic, and potentially relocation of subsurface utilities. RAA5 ranked last because it would result in disruption of residents and businesses in the area, but would result in no improvement in site use. Also, RAA5 would require the construction of a permanent groundwater treatment system in a dedicated building.

13.9.7 Timeliness

RAA1 and RAA2 were ranked first for this criterion because they will require the least amount of time to implement. RAA3, RAA4, and RAA5 would all require the installation of EPEMs identical to those included in RAA1 and RAA2 plus additional remedial technology application, installation and operations. RAA4, RAA3, and RAA5 also provided no improvement in timeliness on a Site-wide basis and were ranked third, fourth, and fifth, respectively.

13.9.8 Non-pecuniary Interests

Each of the RAAs will result in visual and functional improvements to basement floors and walls in individual residences in the neighborhood and to the floor slab at the Property. RAA1 and RAA2 ranked most favorably for this criterion because they do require treatment systems in the neighborhood. RAA3 and RAA5 ranked third because they would require the construction of treatment systems that would have a significant effect on the aesthetic appearance of the area. RAA4 ranked last because of the high number of chemical injection wells that would be visible in private yards, parking areas, driveways, and potentially through floor slabs.

13.10 Selected Remedial Action Alternative

RAA2 is the recommended remedy for the Site because:

- RAA2 will ultimately achieve a Permanent Solution (Class A-3 RAO) and will achieve ROS once all EPEMs are installed.
- RAA2 achieved the second most favorable cumulative rank when compared to other feasible alternatives based on eight criteria specified by the MCP.
- RAA2 is preferable to RAA1 even though RAA1 received a more favorable ranking because RAA2 results in a reduction in the overall mass of contaminants at the Site, meeting the requirement of the RAPS.

The implementation of the selected remedy (RAA2) has been initiated as an IRA and therefore is partially complete.

13.11 Feasibility of Achieving or Approaching Background

None of the RAAs evaluated would achieve background since none could reasonably eliminate dissolved phase contaminants in bedrock groundwater or residual DNAPL potentially present in bedrock fractures. RAA3 – DPE and RAA4 – Chem-Ox were deemed to be ineffective or unreliable in addressing contaminant conditions in bedrock fractures. RAA5 – Hydraulic Control likely could be designed to capture VOC-affected bedrock groundwater, but at a substantial cost and with no reduction in risk at the Site. Therefore, the cost to achieve background was disproportionate to the benefits that might accrue from such extensive remedial actions, and therefore such remedial action are not feasible. This evaluation is consistent with DEP's feasibility policy (WSC-04-160), which states that approaching background for persistent or non-degradable soil contaminants in S-2 or S-3 soil can be deemed infeasible. DNAPL consisting of PCE in bedrock fractures meets the definition of a persistent contaminant and is potentially present in a portion of the Site which is classified as S-2 and S-3. Therefore, approaching background at this Site is considered infeasible.

14. Findings, Conclusions, and Recommendations

The conclusions of the Phase II, Method 3 Risk Characterization, and Phase III are provided below.

14.1 Findings

Based on the information contained in this Phase II CSA, GEI makes the following findings:

A. The Site consists of the Property, residential and commercial properties to the east and immediately north, south and west of the Property, and the Capuano Center.

B. Contaminants identified in soil, groundwater, soil vapor, and indoor air at the Site consist of chlorinated VOCs, particularly PCE. TCE and TCA are also principal COPCs in groundwater and subsurface soil vapor.

C. The Site is underlain by sandy fill, silt, and deep overburden over highly fractured bedrock.

D. Chlorinated VOCs are present in overburden soil at the Property, but are generally not detected in soil above the water table elsewhere at the Site.

E. Chlorinated VOCs (PCE, TCE, and TCA plumes) are present in overburden and bedrock groundwater. The shallow overburden groundwater plume is bounded approximately by Alston Street, Cross Street, Glen Street, Oliver Street, and Franklin Avenue. The deep overburden and bedrock groundwater plumes extend slightly beyond the eastern boundary of the shallow overburden plume at a low concentration.

F. PCE, TCE, and TCA in the form of DNAPLs are present beneath the Property and off-Property to the east and west.

G. Chlorinated VOCs have been detected in indoor air at the Property, in residences and commercial buildings, and at the Capuano Center.

H. An SSDS has been installed at the Property to mitigate the vapor intrusion pathway into the building.

I. An SVE System has been installed at the Property to remove chlorinated VOCs from above the water table. Approximately 3,700 lbs of VOCs had been removed as of May 9, 2008.

J. An SSDS has been installed at the Capuano Center to mitigate the vapor intrusion pathway into the building.

K. EPEMs in the form of SSDS or venting system and vapor barriers have been installed at 12 Morton Street, 18 Morton Street, 23 Tufts Street, 103 Washington Street, 31-33 Knowlton Street, 95 Franklin Street, and 95R Franklin Street.

14.2 Conclusions

Based on the information contained in this Phase II CSA and Phase III RAP, GEI makes the following conclusions:

A. Chlorinated VOCs, particularly PCE, have been measured in soil, groundwater, soil vapor, and indoor air within portions of the Site. TCE and TCA have also been measured in soil, groundwater and soil vapor. These three chlorinated VOCs are the principal chlorinated VOCs at the Site.

B. The chlorinated VOC plumes are stable and at steady-state across the network of monitoring wells in both the overburden and bedrock.

C. DNAPL is not migrating and has reached a stable configuration as a result of capillary trapping forces. The stability of the DNAPL source is reflected by groundwater concentration data collected from monitoring wells within the area of DNAPL occurrence.

D. Vapor intrusion does not represent an increase in the rate of intermedia transfer; it represents an exposure pathway that can be eliminated.

E. As defined by 310 CMR 40.1005(5), subsurface sources at the Site are not resulting in and are not likely to result in an increase in concentrations of OHM in an environmental medium either by direct discharge or by intermedia transfer.

F. Chlorinated VOCs in the indoor air in residences and the Capuano Center represent CEPs which are presumed under the MCP to require prevention, elimination, and/or mitigation to the extent feasible, without regard to risk.

G. The incidence of chlorinated VOCs in indoor air appears to be limited by building condition, building construction and local geology, and to properties located within an area where soil vapor concentrations exceed 10 $\mu g/m^3$.

H. Installation of an SSDS at the Capuano Center has eliminated the CEP to the extent feasible.

I. Mitigation conducted at the Property has achieved a condition of NSR for a Commercial Worker.

J. The EPEMs installed to date at individual residences have effectively controlled the vapor intrusion pathway.

K. EPEMs have been recommended at additional residences to mitigate the vapor intrusion pathway to the extent feasible.

L. Concentrations of chlorinated VOCs in commercial buildings at the Site do not exceed concentrations that would constitute conditions of NSR for a Commercial Worker.

M. Concentrations of chlorinated VOCs at the Site constitute a condition of NSR for utility and construction workers under current and future use.

N. Storm drain and sanitary sewer lines in the southern portion of the Site contain low levels of chlorinated VOCs.

O. Based on the conclusions of the risk characterization, GEI identified three risk-based remedial goals for the Site:

- Eliminate or mitigate potential inhalation exposure to chlorinated VOCs in air inside residences to the extent feasible.
- Eliminate or mitigate potential inhalation exposure to chlorinated VOCs in air inside the Capuano Center to the extent feasible.
- Control potential inhalation exposure of Commercial Workers to chlorinated VOCs in air inside commercial buildings to achieve a condition of NSR.

P. Based on an initial screening of potential remedial technologies, GEI identified five RAAs that could achieve the remedial goals for the Site:

- RAA1 – Site-wide EPEMs and MNA
- RAA2 – SVE at the Property, Site-wide EPEMs and MNA
- RAA3 – DPE at and Immediately East of the Property, MNA, and Downgradient EPEMs
- RAA4 – Chem-Ox at and Immediately East of the Property, MNA, and Downgradient EPEMs
- RAA5 – Hydraulic Control, MNA, and Site-wide EPEMs

Q. The MCP does not specify a time-frame for reaching a Permanent Solution; therefore RAA2 has the potential to achieve a Permanent Solution. The installation of EPEMs to mitigate the vapor intrusion pathway achieves NSR and MNA will ultimately achieve a permanent solution at the Site. Once EPEMs are installed in all buildings as appropriate, the Site will operate in ROS.

R. GEI concluded that RAA2 is the appropriate remedy for the Site because it is timely and cost-effective, it ranked above the other feasible alternatives based on eight criteria specified by the MCP, and it results in a reduction in the overall mass of

contaminants at the Site, meeting the requirements of the RAPS. RAA2 will ultimately achieve a Permanent Solution (Class A-3 RAO) and will achieve ROS once all required EPEMs are installed.

S. It is not feasible to achieve background conditions at the Site because none of the RAAs could reasonably eliminate dissolved phase contaminants in bedrock groundwater or residual DNAPL potentially present in bedrock fractures. The likely cost to address bedrock contamination to achieve background was disproportionate to the benefits that might accrue from such extensive remedial actions, and therefore such remedial actions are not feasible.

14.3 Recommendations

Based on the information contained in this report, GEI makes the following recommendations:

A. Continue to operate the SSDS and SVE at the Property.

B. Continue to operate the SSDS at the Capuano Center.

C. Continue to operate the EPEMs at residences.

D. Modify the EPEMs at residences where they are not operating optimally.

E. Implement EPEMs at residences where they are required due to the presence of a CEP.

F. Complete the evaluation process for the remaining residences and commercial buildings.

G. Complete the evaluation of the storm drain system as requested by DEP.

H. Continue to monitor the groundwater wells to further substantiate that the chlorinated VOCs plume (PCE, TCE, and TCA) is stable.

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Phase II CSA, Method 3 Risk Characterization, & Phase III RAP

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